BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

Joseph C. Mitchell
(1948-2019)

An obituary of the founder and longtime coeditor of *Banisteria*, who was also the leading expert on Virginia's amphibians and reptiles, appears on pages 52–73 of this issue.

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Owlet Moths of Virginia, I. Subfamily Plusiinae (Lepidoptera: Noctuidae)

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ABSTRACT

Twenty-five species of the noctuid moth subfamily Plusiinae are reported for Virginia based on recent collecting, museum specimens, literature records, and photographs. Four species, *Autographa ampla* (Walker), *Polychrysia morigera* (H. Edwards), *Pseudeva purpurigera* (Walker), and *Syngrapha alias* (Ottolengui), are recorded from the Commonwealth for the first time. *Exyra ridingsii* (Riley) may be extirpated in the state, whereas the status of *E. fax* (Grote), *E. semicrocea* (Guenée), and *Plusia putnami* Grote is unknown. Five additional members of the subfamily may occur in the state owing to their documented occurrence in adjacent or nearby states. Documented county and city records and capture dates are reported for all species.

Keywords: new state records, distribution, phenology.

INTRODUCTION

Noctuidae, commonly referred to as "owlet moths," is one of the largest families of Lepidoptera in both the world (ca. 1,089 genera and 11,772 species; van Nieukerken et al., 2011) and North America (>2,500 described species north of Mexico; Lafontaine & Schmidt, 2010) despite the recent splitting of the family into several families (e.g., Erebidae, Euteliidae, Nolidae). At least 475 species of noctuids are known to inhabit Virginia (Roble, unpub. data). This is the first paper in a series that will document the composition, distribution, phenology, and conservation status of the diverse noctuid moth fauna of Virginia. This installment treats the relatively small subfamily Plusiinae (commonly known as loopers), which includes about 400 species worldwide (Powell & Opler, 2009) and 79 species in North America north of Mexico (Lafontaine & Poole, 1991; Lafontaine & Schmidt, 2010). Several plusiines are economically important pests of agricultural crops, but the vast majority are not. Miller et al. (2003) studied the temporal and spatial distribution and abundance of a community of 15 rare to uncommon plusiines in the Pacific Northwest that includes conifer, hardwood tree and shrub, and herbaceous-feeding species, and occupies a range of elevation and habitat types that include subalpine meadows and coniferous forests. These authors concluded that this plusiine fauna represented an important component of the biodiversity within these local landscapes.

Eichlin & Cunningham (1978) reported 15 species of plusiines from Virginia, whereas Pogue (2005) attributed only 12 species to the state. Range maps currently provided on the Moth Photographers Group (hereafter MPG) website include Virginia records for only seven species. They are typically limited to only 1–3 records per species, and are apparently based mostly or entirely on photographs posted on other websites (e.g., BugGuide, Butterflies and Moths of North America) rather than voucher specimens.

As is true of Lafontaine & Poole's (1991) treatment of the Plusiinae and most other fascicles in the landmark series *Moths of North America*, as well as systematic studies and older reviews of the Nearctic moth fauna, few records from Virginia are included. This is largely due to the historical paucity of sampling of the state's native moth fauna by professional and amateur lepidopterists. Most major museum collections contain limited Virginia material, often dominated by the efforts of a single collector (e.g., the Ellison Smyth collection at the National Museum of Natural History [NMNH], primarily from Montgomery County, ca. 1895–1910, or the John Franclemont collection (split between at least NMNH, Cornell University, and the Canadian National Collection of Insects, Arachnids, and Nematodes [CNC]), the Virginia portion of which is almost entirely from Arlington County, ca. 1948–1955) or multiple collectors at the same site (e.g., Mountain Lake Biological Station in Giles County).

The purpose of this paper is to present a more complete summary of our current knowledge on the composition, distribution, phenology, and conservation status of the noctuid subfamily Plusiinae in Virginia.

METHODS

Staff of the Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR-DNH), including the author since 1992, have been sampling the moth fauna of the state for the past three decades, relying primarily on ultraviolet light traps, with more limited use of mercury vapor lights, sugar baiting, Malaise traps, diurnal netting, and other methods. Virtually no larval sampling has been conducted. Most specimens of Plusiinae have been retained from virtually all recent VDCR-DNH samples and that material constitutes the majority of the specimens that I examined for this study. Most specimens collected by VDCR-DNH staff and collaborators are deposited in the National Museum of Natural History (NMNH), Smithsonian Institution, Washington, DC, and the Virginia Museum of Natural History (VMNH), Martinsville, VA, or are retained in a reference collection at the agency's headquarters in Richmond, VA. Specimens collected in national parks (e.g., Shenandoah National Park [SNP], Blue Ridge Parkway [BRP], George Washington Memorial Parkway [GWMP]) have been returned to the respective parks in compliance with U.S. National Park Service policy.

I also searched for Virginia specimens in the following institutional collections: National Museum of Natural History (NMNH), Smithsonian Institution, Washington, D.C.; American Museum of Natural History (AMNH), New York, NY; Carnegie Museum of Natural History (CMNH), Pittsburgh, PA; Academy of Natural Sciences of Drexel University (ANSP), Philadelphia, PA; McGuire Center for Lepidoptera and Biodiversity (MGCL), Florida Museum of Natural History, Gainesville, FL; Cornell University (CUIC), Ithaca, NY; University of Kentucky (UK), Lexington, KY; University of Connecticut (UConn), Storrs, CT; University of Kansas (KU), Lawrence, KS; University of Maryland (UMD), College Park, MD; Pennsylvania State University (PSU), State College, PA; West Virginia University (WVU), Morgantown, WV; Virginia Museum of Natural History (VMNH), Martinsville, VA; Virginia Polytechnic Institute and State University (VPISU), Blacksburg, VA; Virginia Commonwealth University (VCU), Richmond, VA; Virginia Military Institute (VMI), Lexington, VA; and Radford University (RU), Radford, VA. The private collections of Susan Felker (Floyd, VA) and the late William R. Grooms (Ashburn, VA), both currently in the possession of VDCR-DNH, also were examined. Paul Dennehy (Danville, PA), Steve Johnson (Sunbury, PA), and Kelly Richers (Bakersfield, CA) provided records from their private collections. In the species accounts below I have included online (SCAN website) museum records from the University of California-Davis (UCD), Cleveland Museum of Natural History (CLMNH), and Northern Arizona University (NAU), but did not examine those specimens.

No readily accessible database exists for the many plusiine specimens examined for the monograph on the North American fauna prepared by Lafontaine & Poole (1991; J.D. Lafontaine, pers. comm.), which mostly included records from NMNH and CNC. Consequently, I have attempted to estimate the county (or city) of origin for Virginia records based on the position of dots on the range maps in that paper if I was unable to find the likely corresponding specimen(s) during my own museum searches (included NMNH but not CNC).

I also reviewed published and unpublished literature sources (including the annual Season Summary published by The Lepidopterists' Society [SS-TLS] and Virginia regional reports in Southern Lepidopterists' News [SLN]), selected internet websites (including SCAN, LepNet, Yale Peabody Museum, iDigBio, MPG, Butterflies and Moths of North America [BAMONA], BugGuide [BG], iNaturalist [iNat], Maryland Biodiversity Project, North Carolina Biodiversity Project, and the Society of Kentucky Lepidopterists [Covell et al., 2018]), and other readily available photographs (some sent directly to me) for relevant records. Photographic records are listed below only if a voucher specimen is not known to exist from the corresponding county or city. The generalized range maps in Beadle & Leckie (2012) were not considered authoritative for the purpose of determining county or state records.

ANNOTATED CHECKLIST

Twenty-five species of Plusiinae have been documented or reported from Virginia. The checklist numbers of Lafontaine & Schmidt (2010) and Hodges et al. (1983), respectively, precede the species' names. Common names (in brackets) were taken from Covell

(1984), Wagner et al. (2011), Beadle & Leckie (2012), Leckie & Beadle (2018), and the Moth Photographers Group website. The abbreviations MONA and EC78 refer to Lafontaine & Poole (1991) and Eichlin & Cunningham (1978), respectively. Adults of most of the following species are illustrated in popular field guides such as those by Covell (1984), Beadle & Leckie (2012), and Leckie & Beadle (2018), and many are included in the color plates in Pogue (2005). Illustrations of the adults of all of these species can be found in Lafontaine & Poole (1991) and various websites (e.g., MPG, BAMONA, BugGuide, and iNaturalist). Wagner et al. (2011) provided detailed life history summaries and color photos of the larvae for many eastern plusiines, as well as some adult images.

Family Noctuidae

Subfamily Plusiinae

Tribe Abrostolini

931161/8880 *Abrostola ovalis* Guenée
[Oval Nettle Moth, White-shouldered Nettle Moth]

MONA: One record is plotted in either northern Virginia (perhaps Arlington Co.) or the District of Columbia (original source unknown).
Other published Virginia records: State only (EC78).
VDCR-DNH records (7 specimens): Bath Co., Warm Springs Mountain, 10–11 August 2010, S.M. Roble (2); Bedford Co., Jefferson National Forest, Thunder Hill, 20 August 2003, S.M. Roble (1); Dickenson Co., Breaks Interstate Park, Garden Hole, 8 May 2014, S.M. Roble and A.C. Chazal (1); Floyd Co., Buffalo Mountain Natural Area Preserve, 9 July 2010, S.M. Roble (1); Montgomery Co., Sweet Spring Hollow, 1 May 2003, J.C. Ludwig and I.T. Wilson (1); Rockbridge Co., Blue Ridge Parkway, Milepost 45, 30 May 1993, S.M. Roble (BRP, 1).
Other Virginia records: Augusta Co., George Washington National Forest, WVU non-target gypsy moth study, 1995–2001, total of three captures (L. Butler & J. Strazanac, unpub. data). Loudoun Co., Ashburn, 11 June 2010 (W.R. Grooms collection, 1); Smyth Co., Walker Mountain, north of Marion, 36º 54′ N 81º 32′ W, 3650’, 18–19 June 1992, D.C. Ferguson (NMNH, 1).
Photo records: Arlington Co., Arlington, 13 July 2016, K. Rosenthal (iNat); Gloucester Co., Pinetta, 17 August 2006, T. Kain.
Virginia flight dates: 1 May–20 August
Comments: Most of the known Virginia records of *A. ovalis* are from mountains in the western portion of the state (Fig. 1), ranging up to 1210 m (3970′) in elevation, but it has also been observed near sea level in the Coastal Plain and northern Piedmont. I have not been able to determine the source of the material seen by Eichlin & Cunningham (1978) or Lafontaine & Poole (1991). The paucity of Virginia records for this and the following species is surprising given the fact that their larvae feed on stinging nettle (*Urtica dioica* L.) and probably native species of nettles, which are relatively common plants in the mountain and Piedmont regions of the state (Weakley et al., 2012; Virginia Botanical Associates, 2018). This northern moth ranges south to Kentucky, North Carolina, and Tennessee (Lafontaine & Poole, 1991; Pogue, 2005). Forbes (1954) regarded it as a rare species. Due to the limited number of Virginia records, *A. ovalis* is currently placed on the VDCR-DNH Animal Watchlist (Roble, 2016).

931162/8881 *Abrostola urentis* Guenée
[Spectacled Nettle Moth; Nettle Looper]

MONA: Like the preceding species, one record is plotted in either northern Virginia (perhaps Arlington Co.) or the District of Columbia (original source unknown). Forbes (1954) recorded it from the District of Columbia.
Other published Virginia records: State only (EC78), Fairfax Co. (Steury et al., 2007).
VDCR-DNH records: None
Other Virginia records: [City of Richmond], University of Richmond [presumably collected on the campus], 30 May 1936, C.C. Walton (VMNH, 1 [ex University of Richmond collection]); same data but 19 April 1937.
Virginia flight dates: 19 April–26 July, 14 September
Comments: There are very few known records for *A. urentis* in Virginia (Fig. 1). Both specimens from the 1930s have pre-printed "University of Richmond" labels, neither of which contains any annotations identifying an alternate collecting locality (only date and collector's name). However, it should be noted that some of the insects collected by C.C. Walton during the mid-late 1930s were captured in Clifton Forge, Alleghany County (so noted by handwritten annotations on specimen labels) in the western, mountainous area of the state. I have not been able to determine the source of the material seen by Eichlin & Cunningham (1978) or Lafontaine & Poole (1991). This northern moth ranges south to western North Carolina, with an isolated record from southeastern Texas (Lafontaine & Poole, 1991). Powell & Opler (2009) listed South Carolina as the southern range limit in the East. Pogue (2005) did not record *A. urentis* in Great Smoky Mountains National Park, but suggested that it probably occurs there.

Tribe Argyrogrammatini

931166/8885 *Argyrogramma verruca* (F.)
[Golden Looper Moth]

MONA: One or two records are plotted in Virginia (original sources unknown): one dot is in either northern Virginia (perhaps Arlington Co.) or the District of Columbia and the other appears to be in Giles County (probably Mountain Lake area).
Other published Virginia records: State only (EC78).
VDCR-DNH records: Amherst Co., George Washington National Forest, Little Piney Road at Dismal Mountain Road, 1 October 2019, E.C. Orcutt (1).
Other Virginia records: Lancaster Co., 1 mile north of Kilmarnock, 4 September 2012 and 17 October 2012, P. Dennehy (P. Dennehy collection, 2); City of Salem, 23 July 1939, Engel (CMNH, 1).
Photo records: Chesterfield Co., 1 September 2016, J. LeBlanc (BAMONA). Fairfax Co., 1 August 2014, M. O'Donnell (BG, iNat). City of Richmond, 16 August 2015, A. Belden (BAMONA).
Virginia flight dates: 23 July–17 October
Comments: This migratory, tropical species is infrequently found in Virginia (Fig. 2).

931167/8886 *Enigmogramma basigera* (Walker)
[Pink-washed Looper Moth]

MONA: The lone Virginia dot appears to be plotted in the City of Virginia Beach (original source unknown).
Other published Virginia records: State only (EC78); Hanover Co. (Ludwig, 2009); City of Virginia Beach (Bastian, 2011; photograph).
VDCR-DNH records (7 specimens): Accomack, Chesterfield, Hanover, and Northampton counties and City of Virginia Beach.
Other Virginia records: Arlington (CUIC, 1), Floyd (S. Felker collection, 1), Lancaster (P. Dennehy collection, 9), and New Kent (CMNH, 2) counties; City of Suffolk (UCD, 1).
Photo records: Fairfax Co. (BAMONA, BG, iNat), City of Richmond (BAMONA).
Virginia flight dates: 16 July–28 October
Comments: Most of the few known Virginia records for this species are from the eastern portion of the state (Fig. 3). It was formerly placed in the genus *Argyrogramma* (Covell, 1984).

931168/8887 *Trichoplusia ni* (Hübner)
[Cabbage Looper Moth]

MONA: Up to four records are plotted in Virginia (original sources unknown), which I estimate as Arlington, Frederick, Montgomery, and Prince William counties for the purposes of Figure 4.
Other published Virginia records: State only (EC78); Hanover Co. (Ludwig, 2000, 2009); Tazewell Co. (Stein, 1993); City of Virginia Beach (Bastian, 2011).
VDCR-DNH records (15 specimens): Brunswick/Dinwiddie, Hanover, Highland, Northampton, and Patrick counties and City of Virginia Beach.
Other Virginia records: Loudoun (W.R. Grooms collection, 1), Montgomery (UK, 1; VPISU, 1), and Westmoreland (NAU, 1) counties and the cities of Norfolk (VPISU, 1) and Virginia Beach (CLMNH, 1).
Photo records: Carroll (W. Cook), Fauquier (BAMONA, larva) and Stafford (BG) counties and the cities of Newport News (BG, larva) and Richmond (BAMONA).
Virginia flight dates: 15 June–30 October
Comments: This species occurs in a wide variety of habitats in Virginia. It feeds on many species of herbaceous plants and can be a serious pest of cabbage crops (Powell & Opler, 2009). The New World range extends south into tropical America (Forbes, 1954). According to Lafontaine & Poole (1991), *T. ni* is "the most widespread species of Plusiinae and one of the more globally distributed species in the family Noctuidae." Previously thought to be an Old World species that is now widely distributed on several continents, including North America (Zahiri et al., 2017; supplemental Table S3), recent genetic evidence suggests the Old and New World populations may represent distinct species (J.D. Lafontaine, pers. comm). Regarding the status of *T. ni* in the Northeast, Wagner (2005) noted "In recent years it has become curiously scarce…" He also stated that the northern latitude at which North America populations of *T. ni* successfully overwinter is unknown and migrants from the south reestablish northern populations each spring.

931169/8889 *Ctenoplusia oxygramma* (Geyer)
[Sharp-stigma Looper Moth]

MONA: One or two records are plotted in Virginia (original sources unknown): one dot is in either northern Virginia (perhaps Arlington Co.) or the District of Columbia and the other is in the City of Virginia Beach.
Other published Virginia records: State only (EC78); Fairfax Co. (Steury et al., 2007); Hanover Co. (Ludwig, 2000, 2009).
VDCR-DNH records (17 specimens): Amherst, Brunswick, Craig, Hanover, Isle of Wight, Montgomery, New Kent, and Prince William counties and the City of Virginia Beach.

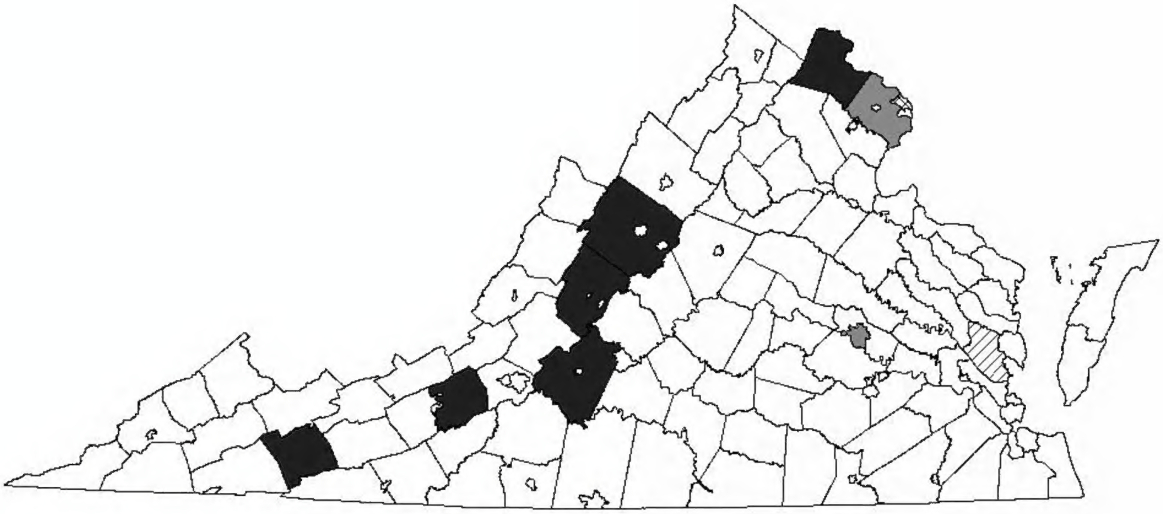

Fig. 1. County and city distribution of *Abrostola ovalis* (dark shading = voucher specimens, diagonal shading = photographs) and *A. urentis* (light shading; voucher specimens) in Virginia. Both species have been documented in Arlington County (cross hatching) and/or the District of Columbia.

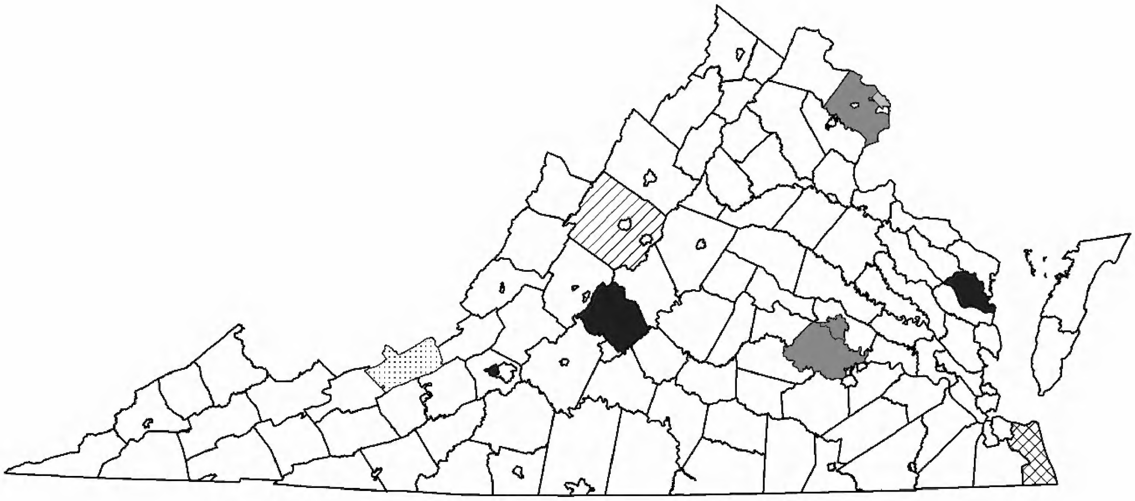

Fig. 2. County and city distribution of *Argyrogramma verruca* (dark shading = voucher specimens, medium shading = photographs; stippling = estimated county or city locations of points mapped by Lafontaine & Poole [1991]) and *Rachiplusia ou* (diagonal hatching = photographs; cross hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]) in Virginia. The range maps in Lafontaine & Poole (1991) for both species include a point in or near Arlington County (light shading) or the District of Columbia.

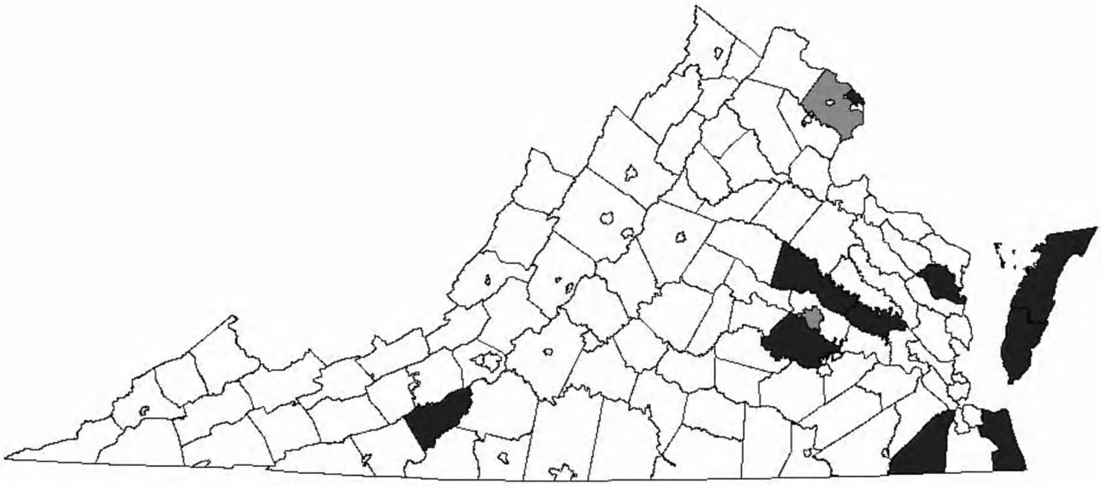

Fig. 3. County and city distribution of *Enigmogramma basigera* in Virginia (dark shading = voucher specimens, light shading = photographs).

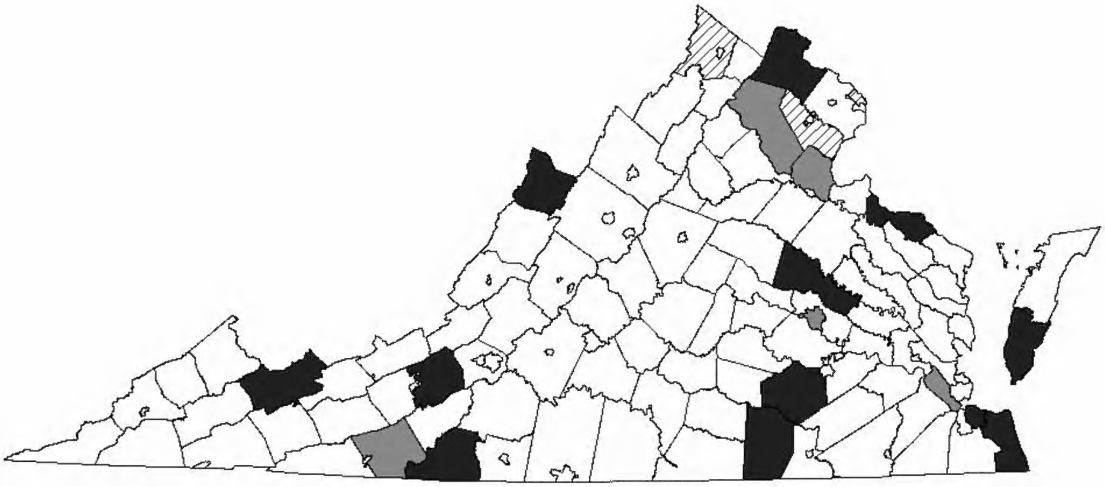

Fig. 4. County and city distribution of *Trichoplusia ni* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

Other Virginia specimen records: Lancaster Co. (P. Dennehy collection, 9); City of Hampton (VPISU, 1).
Photo records: Chesterfield (BAMONA, BG), Powhatan (J. Reilly), and Tazewell (BAMONA) counties; City of Richmond (BAMONA).
Virginia flight dates: 3 June; 2 August–2 November.
Comments: This species apparently occurs sporadically in Virginia (Fig. 5). Its range extends southward into tropical America (Forbes, 1954). It was formerly placed in the genus *Agrapha* (Covell, 1984).

931170/8890 *Chrysodeixis includens* (Walker)
[Soybean Looper Moth]

MONA: As many as seven widely scattered dots are plotted in Virginia (original sources unknown) for this widespread, primarily tropical species. For the purposes of Figure 6, I estimate these locations correspond to sites in Arlington, Augusta, Frederick, James City, Prince George, and Montgomery counties and the City of Virginia Beach.
Other published Virginia records: State only (EC78); Fairfax (Steury et al., 2007), Hanover (Ludwig, 2000, 2009), and Wise (Holl, 1996) counties; City of Virginia Beach (Bastian, 2011).
VDCR-DNH records (125 specimens): Accomack, Alleghany, Augusta, Bath, Bedford, Charlotte, Chesterfield, Dickenson, Fairfax, Floyd, Giles, Halifax, Hanover, Henry, Isle of Wight, Montgomery, Northampton, Northumberland, Prince William, Roanoke, Rockbridge, Southampton, Washington, Wise, and Wythe counties and the cities of Suffolk and Virginia Beach.
Other Virginia records: Giles (VPISU, 3), Lancaster (P. Dennehy collection, 5), Loudoun (W.R. Grooms collection, 5), Madison (UCD, 1), Montgomery (VPISU, 1), Pulaski (UCD, 1), and Rockingham (K. Richers collection, 3) counties and the cities of Manassas (MGCL, 1), Norfolk (VPISU, 2), Richmond (VCU, 1), Suffolk (VPISU, 1), and Virginia Beach (CLMNH, 1).
Photo records: Arlington (BAMONA, BG, iNat), Clarke (iNat), Gloucester (T. Kain), Henrico (BAMONA), James City (BAMONA, iNat), Page (BG), Pittsylvania (iNat), Powhatan (J. Reilly), Shenandoah (BAMONA), Stafford (BG), Tazewell (BAMONA), Warren (BAMONA, iNat), Westmoreland (iNat), and York (BAMONA) counties and the cities of Alexandria (iNat), Chesapeake (BAMONA, iNat), Colonial Heights (BAMONA), and Hampton (BG).
Virginia flight dates: 7 January; 17 April–3 November
Comments: I collected an adult *C. includens* at the incandescent porch light of my residence in Chesterfield County on 7 January 2008, presumably an unusually late rather than early date. This is the most common and widespread plusiine in Virginia (Fig. 6), probably occurring in every county in the state. Most records may be of moths that have migrated north in the spring and summer from more southerly latitudes to establish temporary breeding populations that persist until the onset of freezing temperatures. Its range extends southward into tropical America (Forbes, 1954). *Chrysodeixis includens* is an economically important species as its common name implies. It was formerly placed in the genus *Pseudoplusia* (Covell, 1984; Lafontaine & Schmidt, 2010).

Tribe Plusiini

931176/8895 *Rachiplusia ou* (Guenée)
[Gray Looper Moth]

MONA: Like *Ctenoplusia oxygramma*, one dot is plotted in either northern Virginia (perhaps Arlington Co.) or the District of Columbia and a second dot corresponds to the City of Virginia Beach (original sources unknown).
Other published Virginia records: State only (EC78).
VDCR-DNH records: None.
Photo records: Augusta Co., Staunton, 7 September 2012, M. Morris (BG).
Virginia flight dates: 7 September
Comments: I have not been able to determine the source of the material seen by Eichlin & Cunningham (1978) or Lafontaine & Poole (1991). Apparently, there are very few records of this species from Virginia (Fig. 2). Its range extends south to Ecuador (Powell & Opler, 2009).

931177/8898 *Allagrapha aerea* (Hübner)
[Unspotted Looper Moth]

MONA: Surprisingly, only three dots are plotted in Virginia (original sources unknown) for this common species, which I estimate correspond to Giles and Smyth counties and the City of Suffolk.
Other published Virginia records: State only (EC78); Augusta (Butler et al., 2001), Bath (Skinner, 1921; CMNH, 1), Fairfax (Steury et al., 2007), and Hanover (Ludwig, 2000, 2001, 2002, 2009) counties; City of Virginia Beach (Bastian, 2011).
VDCR-DNH records (51 specimens): Amherst, Augusta, Bedford, Botetourt, Chesterfield, Craig, Dickenson, Dinwiddie, Fairfax, Fauquier, Floyd, Hanover, Isle of Wight, Lee, Montgomery, Nottoway, Prince William, Russell, Scott, Stafford, Sussex, Washington, and Wise counties.
Other Virginia records: Bedford (VPISU, 1), Floyd (S. Felker collection, 1), Giles (VPISU, 1), Loudoun (W.R.

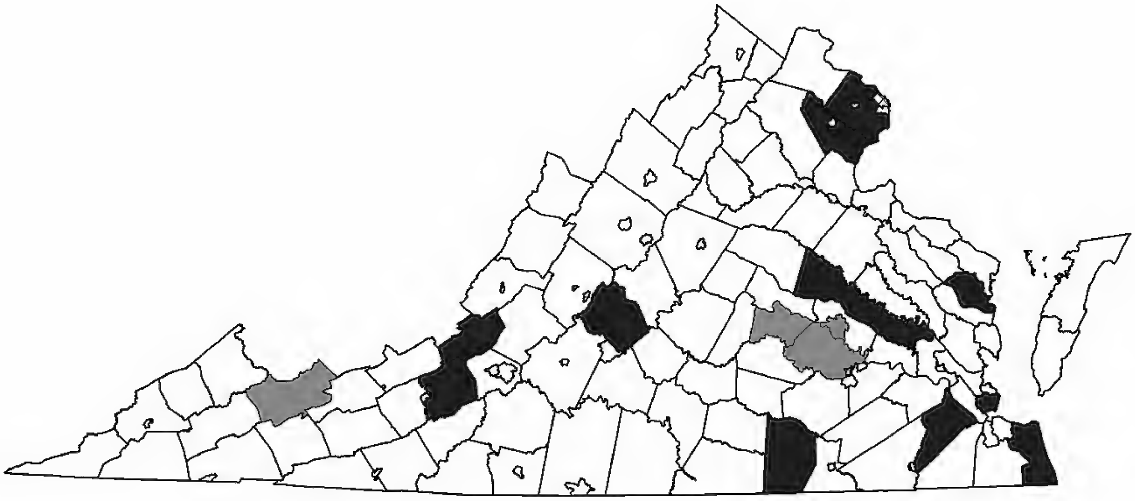

Fig. 5. County and city distribution of *Ctenoplusia oxygramma* in Virginia (dark shading = voucher specimens, light shading = photographs, cross hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991).

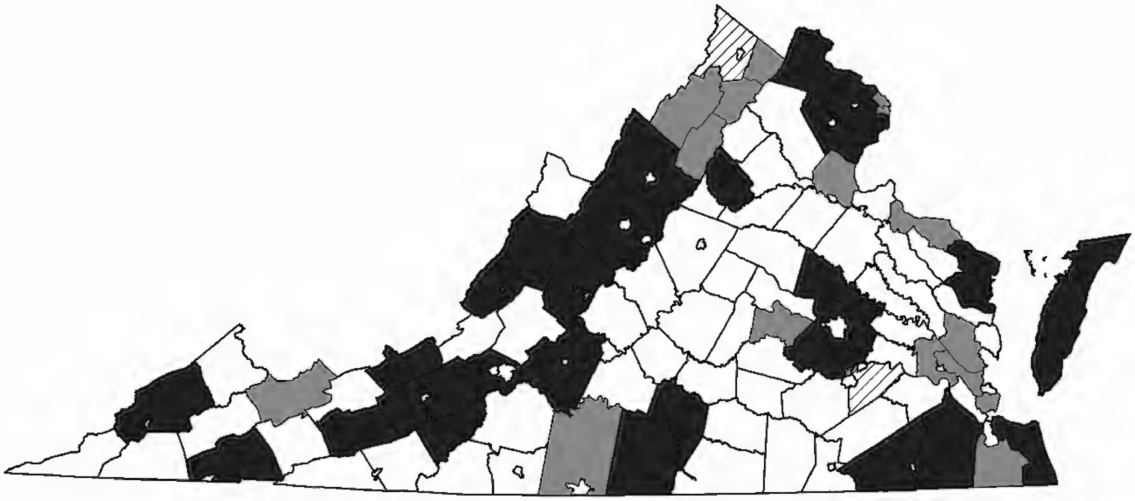

Fig. 6. County and city distribution of *Chrysodeixis includens* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

Grooms collection, 2; VPISU, 1), Montgomery (VPISU, 1), Rockbridge (US Forest Service non-target gypsy moth study, J. Peacock et al., unpub. data), and Rockingham (K. Richers collection, 1) counties; City of Radford (S. Felker collection, 1).
Photo records: Culpeper (iNat) and Powhatan (J. Reilly) counties; cities of Lynchburg (iNat), Richmond (BAMONA), and Salem (iNat).
Virginia flight dates: 8 May–25 October
Comments: This species is widespread in Virginia (Fig. 7).

931178/8896 *Diachrysia aereoides* (Grote)
[Dark-spotted Looper Moth, Lined Copper Looper]

MONA: No records, but there is a locality plotted in extreme southeastern Kentucky near the Virginia border. Covell (1999) reported *D. aereoides* from two localities in Kentucky, including Big Black Mountain, Harlan County, which borders Lee County, VA, the westernmost county in the state.
Published Virginia records: Fairfax Co. [Great Falls Park, 14 August 2004, J. Glaser, GWMP, 1] (Steury et al., 2007; B. Steury, pers. comm.).
VDCR-DNH records (7 specimens): Bath Co., Warm Springs Mountain, Bald Knob, 7 July 1999, J.C. Ludwig (1). Grayson Co., Jefferson National Forest, Whitetop Mountain, 22 July 2014, S.M. Roble (3). Highland Co., George Washington National Forest, South Fork Locust Spring Run, 29 July 1999, S.M. Roble (1). Smyth Co., Jefferson National Forest, Whitetop Mountain, 30 June 2010, S.M. Roble (1). Washington Co., Jefferson National Forest, Whitetop Mountain, 30 June 2010, S.M. Roble (1).
Virginia flight dates: 7 July–14 August
Comments: This attractive, pink and gold moth has a transcontinental range in northern North America (Newfoundland and Nova Scotia to British Columbia and northern California), extending south in the East to Maryland, Kentucky, and western North Carolina (Lafontaine & Poole, 1991). Covell (1999) noted that *D. aereoides* is rare in Kentucky. Butler & Strazanac (2014) listed records for five counties in eastern West Virginia, and Pogue (2005) reported four specimens, each from a different site, in Great Smoky Mountains National Park near the North Carolina-Tennessee border.

Diachrysia aereoides was not recorded for Virginia by Eichlin & Cunningham (1978) or Lafontaine & Poole (1991). Apparently the first Virginia specimen was not collected until 1999. Most of the few Virginia records of this species are from high elevation sites (1073–1676 m [3520–5500′]; Fig. 8), but there is a recent collection from much lower elevation (≤100 m) in Great Falls Park in the northern Piedmont (Steury et al., 2007).

931179/8897 *Diachrysia balluca* Geyer
[Green-patched Looper Moth, Hologram Moth, Splendid Brass Looper]

MONA: One record is plotted in western Virginia, probably at or near Mountain Lake in Giles County (original source unknown). There is also a record from extreme southeastern Kentucky near the Virginia border. Covell (1999) reported *D. balluca* from two localities in Kentucky, one of which is Big Black Mountain in Harlan County (borders Virginia), and regarded this species as rare in that state.
Other published Virginia records: Bath Co. (Skinner, 1921; Hot Springs [Warm Springs Mountain, 31 July 1916, M. Hebard, CMNH (1)]). Wise Co. (Holl, 1996).
VDCR-DNH records (3 specimens): Bath Co., Warm Springs Mountain, Bald Knob, 15 June 1999, J.C. Ludwig (1), Warm Springs Mountain, 1 km S VA Rt. 39, 6 July 1999, J.C. Ludwig (1). Washington Co., Clinch Mountain Wildlife Management Area, Big Tumbling Creek, 2500’, 20 September 2011, S.M. Roble (1).
Other Virginia records: None known.
Virginia flight dates: 15 June–20 September. This range of dates exceeds that of the rangewide collection period of “late July to early September” reported by Lafontaine & Poole (1991).
Comments: This is the largest plusiine in Virginia (wingspan 40–50 mm; Forbes, 1954) and perhaps the most beautiful, possessing metallic gray green forewings with a hint of pink. It was first collected in the state more than a century ago by Morgan Hebard, an orthopterist from the Academy of Natural Sciences in Philadelphia, and has been taken only three times in the past three decades during statewide sampling by VDCR-DNH biologists. Two of the recent records are from sites on the same mountain as the cabin occupied by Hebard (exact location unknown) in the summer of 1916. One of the recent Warm Springs Mountain sites is a xeric pitch pine-scrub oak ridgetop barren (Bald Knob, 1289 m [4229′]), whereas the other site is in a nutrient rich forest (945 m), as is the Washington County site (762 m). All Virginia records are from mountainous areas (Fig. 8), including two lower elevation sites at or below 762 m (2500′).

Pogue (2005) recorded *D. balluca* from one peak (1475–1501 m) in the North Carolina portion of Great Smoky Mountains National Park at or near its southern range limit. The 19th century Titian Peale collection at ANSP contains two specimens of *D. balluca*, one each

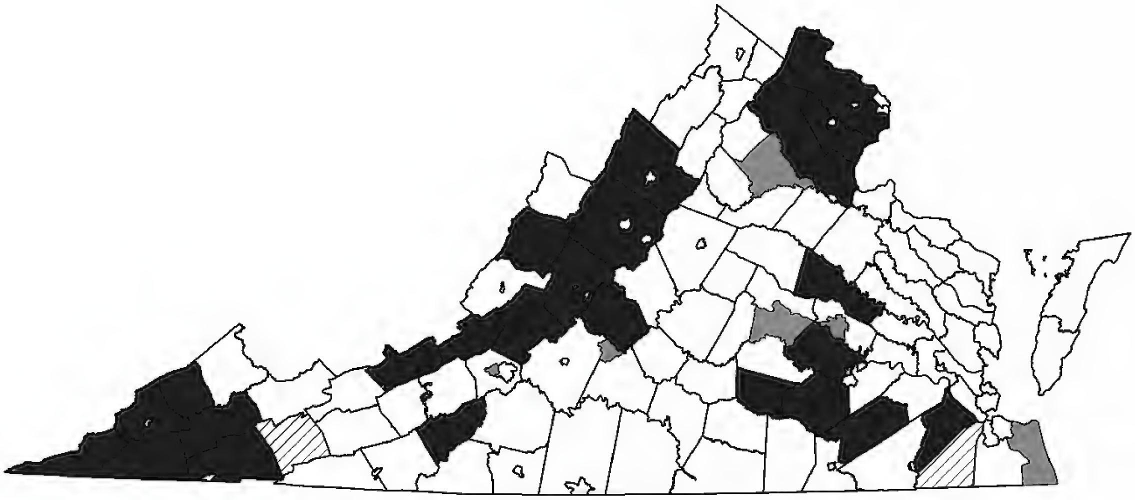

Fig. 7. County and city distribution of *Allagrapha aerea* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

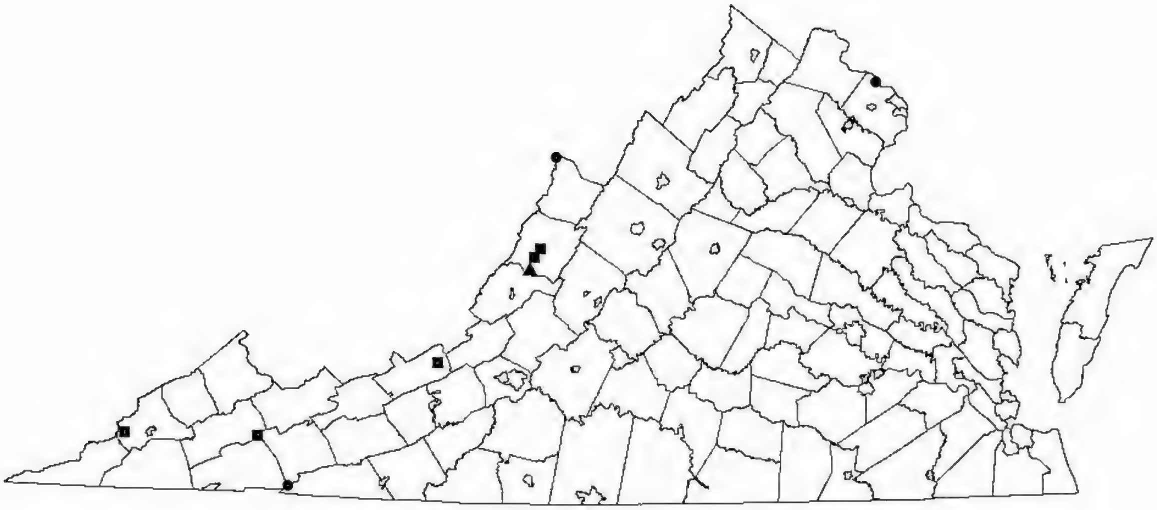

Fig. 8. Distribution of *Diachrysia aereoides* (circles) and *D. balluca* (squares) in Virginia (voucher specimens). Both species were collected on Bald Knob, Warm Springs Mountain (triangle) in Bath County. One location for *D. balluca* (mapped at Mountain Lake, Giles Co.) is estimated based on the lone Virginia record plotted on the range map in Lafontaine & Poole (1991).

from the District of Columbia (mounted between 1846 and 1863) and York County, Pennsylvania (no date; ANSP website). Neither of these localities appears on the range map in Lafontaine & Poole (1991). This species is likely extirpated in at least the Washington area. Due to the limited number of Virginia records, *D. balluca* is currently placed on the VDCR-DNH Animal Watchlist (Roble, 2016).

931183/8902 *Polychrysia morigera* (H. Edwards)
[No common name] (Fig. 15)
NEW STATE RECORD

This is one of the rarest North American plusiines despite having a widespread distribution (Lafontaine & Poole, 1991). It has apparently expanded its range eastward in recent decades.

The range map in Eichlin & Cunningham (1978) includes records for only five western states, whereas Lafontaine & Poole (1991) reported that it occurs as far east as Tennessee, Kentucky, West Virginia, and western Pennsylvania. Covell (1999) stated that *P. morigera* is local and uncommon in Kentucky (records for nine counties), with the first known specimen record for that state taken in 1976, and the first in Tennessee a decade later. Butler et al. (2001) reported a single capture during a 2-year survey (1995–96) on the Monongahela National Forest in Pocahontas County, West Virginia, not far from the Virginia border (see comments below). Pogue (2005) collected four specimens in the North Carolina portion of Great Smoky Mountains National Park.

The first known Virginia specimen of *P. morigera* was collected by the late Douglas C. Ferguson of the National Museum of Natural History, Smithsonian Institution: Smyth Co.: Walker Mountain, north of Marion, 36° 54′ N 81° 32′ W, 3650′, 18 June 1992 (NMNH, 1). VDCR-DNH staff have since taken 13 additional specimens at six sites in the southwestern portion of the state (Fig. 9), mostly in limestone habitats: Botetourt Co., private timber tract along Catawba Creek, 22 May 2001, A.C. Chazal and K.L. Derge (2); same site but 15 June 2001, A.C. Chazal and C.S. Hobson (1). Dickenson Co.: Breaks Interstate Park, Russell Fork River, Garden Hole, 3 June 2008, S.M. Roble and A.C. Chazal (1). Lee Co.: The Cedars Natural Area Preserve, Dry Creek barrens, 25 May 2000, C.S. Hobson (2). Montgomery Co.: Allen Hollow, 18 June 2003, J.C. Ludwig and I.T. Wilson (3); Slaughterpen Hollow, 10 June 2001, J.C. Ludwig (1). Russell Co.: Cleveland Barrens Natural Area Preserve, 23–24 May 2001, C.S. Hobson (3).
Virginia flight dates: 22 May–18 June
Comments: One specimen of *P. morigera* was captured on the George Washington National Forest in Augusta County (L. Butler & J. Strazanac, unpub. data) during the long-term (1995–2001) non-target gypsy moth study discussed by Butler et al. (2001; only 1995–1996 data were summarized for this paper), but it was not retained (absent from WVU collection, pers. obs.). Due to the limited number of Virginia records, *P. morigera* is currently placed on the VDCR-DNH Animal Watchlist (Roble, 2016). Powell & Opler (2009) reported that this species is not very attracted to lights although it sometimes occurs at them in good numbers. The larvae feed on wild larkspurs (*Delphinium* spp.) (Lafontaine & Poole, 1991).

931184/8899 *Pseudeva purpurigera* (Walker)
[Straight-lined Looper Moth]
NEW STATE RECORD

Published Virginia records: None known.
VDCR-DNH records (8 specimens): Bath Co., Warm Springs Mountain, 6 July 1999, J.C. Ludwig (2). Botetourt Co., private timber tract along Catawba Creek, 15 June 2001, A.C. Chazal (4). Lee Co., The Cedars Natural Area Preserve, 19 June 2000, C.S. Hobson (1). Montgomery Co., Slaughterpen Hollow, 10 June 2001, J.C. Ludwig (1).
Other Virginia records: None known.
Virginia flight dates: 10 June–6 July
Comments: This species was not recorded for Virginia by Eichlin & Cunningham (1978) or Lafontaine & Poole (1991), and I have not found any other published sources attributing this moth to the Virginia fauna. The range of *P. purpurigera* is primarily northern (Atlantic Coast to Rocky Mountains), extending south in the East to Delaware, Kentucky, and North Carolina (Lafontaine & Poole, 1991). Glaser et al. (unpublished) recorded this species from two sites in far western Maryland (Garrett Co.), and Butler & Strazanac (2014) listed one record for each of three counties (Lincoln, Preston, Wayne) in West Virginia. Pogue (2005) collected one specimen of *P. purpurigera* in the North Carolina portion of Great Smoky Mountains National Park. Powell & Opler (2009) stated that South Carolina is the southern range limit in the East, whereas Wagner et al. (2011) reported the mountains of Georgia.

This species is uncommon to rare southward and the larvae feed on meadow-rue (*Thalictrum*) (Covell, 1984). Concerning the status of *P. purpurigera* in Delaware, Jones (1928–1939) wrote “Rarely seen unless bred from the larvae, which some seasons are fairly abundant.” The Virginia records (Fig. 10) essentially fill the gap between

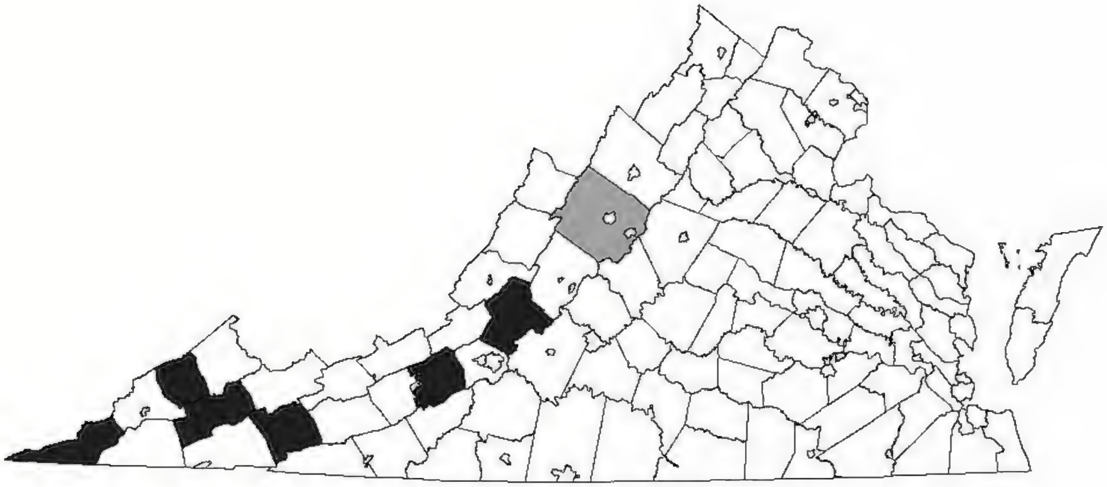

Fig. 9. County and city distribution of *Polychrysia morigera* in Virginia (dark shading = voucher specimens, light shading = discarded specimen [see text]).

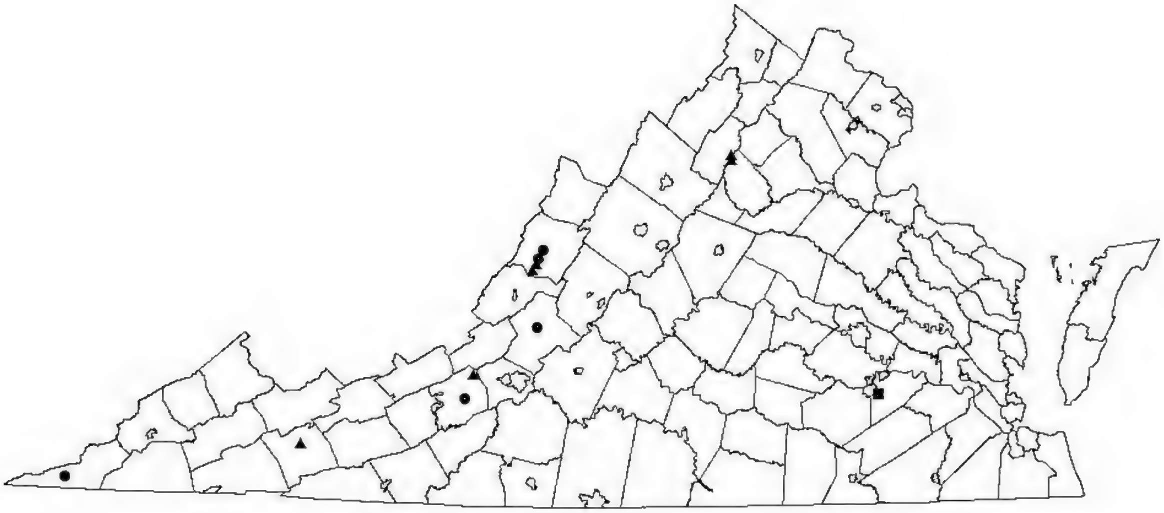

Fig. 10. Distribution of *Autographa ampla* (triangles), *Exyra ridingsii* (square), and *Pseudeva purpurigera* (circles) in Virginia (voucher specimens). *Autographa ampla* and *P. purpurigera* were collected at two sites each on Warm Springs Mountain in Bath County.

the Delaware and North Carolina records plotted by Lafontaine & Poole (1991).

931186/8904 *Chrysanympha formosa* (Grote)
[Formosa Looper Moth; Beautiful Looper]

MONA: One record is plotted in western Virginia (perhaps Alleghany or Bath Co.; original source unknown). There is also a record shown in extreme southeastern Kentucky near the Virginia border. Covell (1999) reported *C. formosa* from four localities in Kentucky, including Pine Mountain State Resort Park in Bell County, the latter of which is adjacent to Lee County, VA, the westernmost county in the state.
Other published Virginia records: State only (EC78); Augusta (Butler et al., 2001), Bath (Skinner, 1921; ANSP, 1), Giles (Milne & Milne, 1944), Hanover (Ludwig, 2001, 2002, 2009), Madison (Manderino et al., 2014), Montgomery (SLN, September 1988), Page (Manderino et al., 2014), Rappahannock (Manderino et al., 2014), and Rockbridge (Wagner et al., 1995) counties.
VDCR-DNH records (36 specimens): Alleghany, Bath, Bedford, Botetourt, Craig, Dickenson, Fauquier, Floyd, Frederick, Hanover, Isle of Wight, King and Queen, Patrick, Prince William, Rockbridge, and Wise counties and the cities of Suffolk and Virginia Beach.
Other Virginia records: Amherst (CMNH, 1), Giles (NMNH, 1), Montgomery (NMNH, 3), Nelson (NMNH, 1), and Rockingham (K. Richers collection, 2) counties and the City of Virginia Beach (NMNH, 3).
Virginia flight dates: 19 May–23/26 July
Comments: This species is widely distributed in Virginia but not often collected (Fig. 11). Most specimens were captured in June. During the WVU non-target gypsy moth study conducted on the George Washington National Forest in Augusta County, 164 adult specimens of *C. formosa* were captured during 102 successful sampling events (1.6 specimens/trap, nearly all of which were discarded), more than double the combined total (n = 70) captures for the eight other plusiines recorded (L. Butler & J. Strazanac, unpub. data).

Chrysanympha formosa ranges south to the mountains of Georgia (Wagner et al., 2011). Pogue (2005) recorded this species at only four sites in Great Smoky Mountains National Park near the North Carolina-Tennessee border.

931187/8905 *Eosphoropteryx thyatyroides*
(Guenée)
[Pink-patched Looper Moth]

MONA: One record appears to be plotted in extreme northwestern Virginia (perhaps Frederick Co. or the City of Winchester; original source unknown). The range map also displays a record in extreme southeastern Kentucky. Covell (1999) reported *E. thyatyroides* from 11 Kentucky counties, including Harlan Co. (Big Black Mountain), which borders Lee County, VA, the westernmost county in the state.
Other published Virginia records: State only (Holland, 1903; Forbes, 1954; Eichlin & Cummingham, 1978); Giles (SS-TLS, 1992), Page, Rappahannock, and Warren counties (all Manderino et al., 2014).
VDCR-DNH records (16 specimens): Bath, Bedford, Floyd, Highland, Page, Rockingham, Russell, Scott, Washington, and Wise counties.
Other Virginia records: Augusta Co., George Washington National Forest, WVU non-target gypsy moth study, 1995–2001, total of two captures (L. Butler & J. Strazanac, unpub. data). Floyd Co. (S. Felker collection, 1).
Photo records: Tazewell Co. (BAMONA).
Virginia flight dates: 17 June–7 October
Comments: This species is collected infrequently in the mountains of western Virginia (Fig. 12). During a 2011 non-target gypsy moth study, Manderino et al. (2014, Appendix S2; four trapping periods) collected 10 adult specimens of *E. thyatyroides* at six of 15 sampling sites near Skyline Drive in Shenandoah National Park. The range of this species extends south to the mountains of Georgia (Wagner et al., 2011). The larvae feed on meadow-rues (*Thalictrum* spp.) and wild columbine (*Aquilegia*) (Powell & Opler, 2009), and possibly also on lousewort (*Pedicularis*; Wagner et al., 2011).

931188/9021 *Exyra fax* (Grote)
[Pitcher Plant Moth; Pitcherplant Looper; Epauletted Pitcher-plant Moth]
No map

931189/9024 *Exyra semicrocea* (Guenée)
[Pale Shoulder Pitcherplant Looper; Pitcherplant-mining Looper]
No map

931190/9023 *Exyra ridingsii* (Riley)
[Riding's Pitcherplant Looper]

Exyra is a small but fascinating genus of small noctuid moths. All three of its members are pitcher plant (*Sarracenia* spp.) specialists, their larvae feeding on the leaves (pitchers) of these carnivorous plants and the adults often taking refuge inside of them (Jones, 1921; Folkerts & Folkerts, 1996; Wagner et al., 2011). Jones

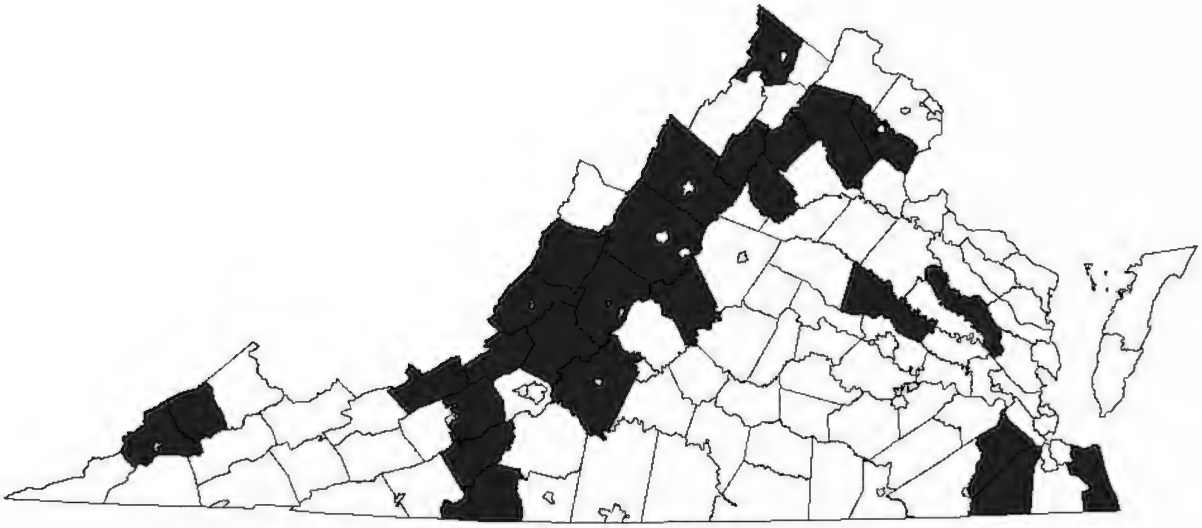

Fig. 11. County and city distribution of *Chrysanympha formosa* in Virginia (voucher specimens).

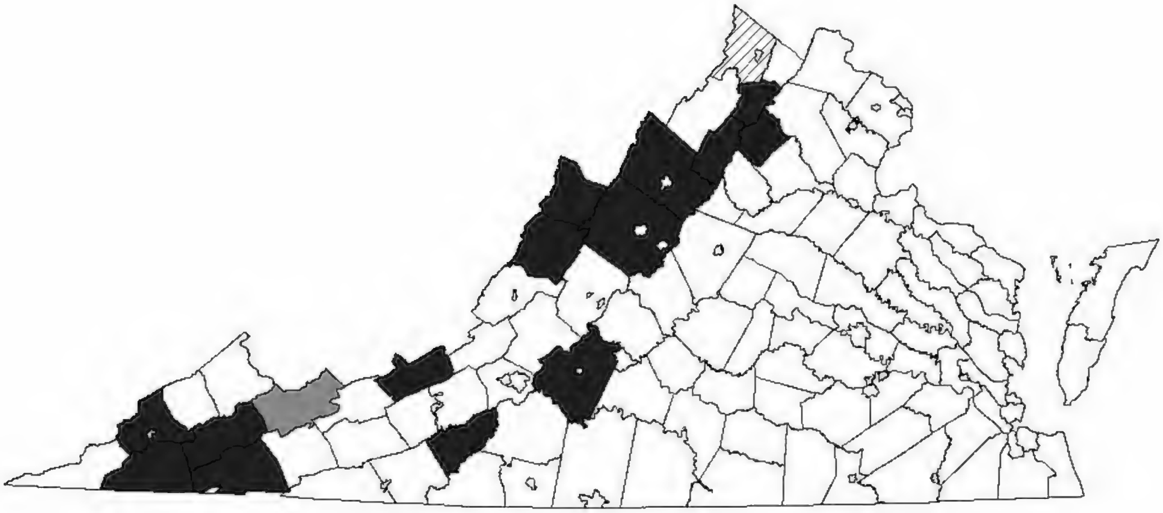

Fig. 12. County and city distribution of *Eosphoropteryx thyatyroides* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

(1921) reported that two of these species are associated with only one species of pitcher plant each, whereas the third (*E. semicrocea*) is found on several species of pitcher plants. He stated that North Carolina was the northern range limit for both *E. ridingsii* and *E. semicrocea*, whereas *E. fax* (= *E. rolandiana* Grote) is a more widespread species, ranging from Canada south to the Gulf of Mexico. Holland (1903) and Forbes (1954) reported New Jersey as the northern range limit of *E. semicrocea*, and the latter author remarked that *E. ridingsii* was "found as far north as North Carolina at least." Schweitzer et al. (2011) concluded that reports of *E. ridingsii* from New Jersey were based on misidentifications of the superficially similar *Ponometia semiflava* (Guenée). Lafontaine & Poole (1991), Hall et al. (1999), and Schweitzer et al. (2011) all listed the range of *E. ridingsii* as the Coastal Plain (and Sand Hills region) from North Carolina south to Florida and west to Alabama; Wagner et al. (2011) cited a similar range (minus Alabama) for this species. Genetic differences have been documented between populations of *E. semicrocea* (Stephens et al., 2011).

No Virginia records for any species of *Exyra* were plotted on the detailed range maps prepared by Lafontaine & Poole (1991), whereas the text and generalized maps in Folkerts & Folkerts (1996) indicate that *E. ridingsii* and *E. semicrocea* reach their northern limits in southeastern Virginia. This is plausible based on the known ranges of their hostplants, but I was unable to determine the source(s) of these Virginia records. No Virginia specimens of *Exyra* are included in the Folkerts collection at Auburn University (M. Callahan, pers. comm.). However, I found two previously unsorted specimens of *E. ridingsii* in the Virginia Museum of Natural History with the following label data (brackets added): [Prince George Co.:] South of Petersburg, in pitcher plants in bog, 25 June 1936, C. Williams (VMNH [ex. University of Richmond collection], 2). The collector, Carroll E. Williams, was an undergraduate student in the biology department at the University of Richmond at that time and later became a renowned professor at Harvard University, eventually being elected to the National Academy of Sciences (Telfer, 1992; Pappenheimer, 1995). On this date in 1936, Williams accompanied several of his professors and renowned Harvard University botanist Merritt Lyndon Fernald to rare or unusual habitats in southeastern Virginia in search of rare plants (Fernald, 1937: 323).

The hostplant of *E. ridingsii* is *Sarracenia flava* L. (yellow pitcher plant or trumpets), an austral species that is very rare in Virginia, with documented records for only nine counties and cities in the southeastern corner of the state (Porter, 1991; Weakley et al., 2012; Virginia Botanical Associates, 2018). Most of the historically known populations of *S. flava* in Virginia are now extirpated as a result of habitat destruction (e.g., ditching, draining, filling), degradation (e.g., heavy grazing/trampling), or succession (woody plant encroachment due to prolonged fire suppression), including a large ("many acres"; Fernald, 1937) boggy depression southeast of Petersburg in northwestern Prince George County. The precise location of this destroyed bog is unknown but is estimated (Fig. 10) based on information in Fernald (1937) and the VDCR-DNH rare species database. The habitat and rare plants (*S. flava* was "gratifyingly abundant") of the bog where Williams collected *E. ridingsii* were described by Fernald (1937: 325–326, 334–335). Elsewhere in his narrative, Fernald lamented the destruction of other pitcher plant bogs by ditching or their severe degradation by livestock (Fernald, 1937: 335, 338–339). Currently, less than five extant native populations of *S. flava* are known in Virginia, most of which are very small (VDCR-DNH rare species database). Consequently, *E. ridingsii* may be extirpated in the state. This species is currently placed on the VDCR-DNH Rare Animal List (Roble, 2016).

I did not find data on any Virginia specimens of *E. fax* or *E. semicrocea*. It is unclear from the generalized map in Folkerts & Folkerts (1996) if Virginia is included in the range of *E. fax*. The larvae of this species feed on *Sarracenia purpurea* L. (purple pitcher plant), a primarily northern species that was historically documented in 16 counties and cities in coastal Virginia (Virginia Botanical Associates, 2018), but is now reduced to about 15 remnant populations (VDCR-DNH rare species database). Perhaps *E. fax* will eventually be found at one of these sites. The larvae of *E. semicrocea* feed on *S. flava* and other, more southern congeners that are not native to Virginia. It is unlikely that this moth still inhabits Virginia, if it ever did.

Stephens et al. (2011) and Stephens & Folkerts (2012) reported that pitcher plant bogs in the southeastern United States Coastal Plain have been reduced to about 3% of their former range due to habitat loss and fragmentation, and indicated that *Exyra* moths are thus deserving of conservation concern.

931191/8908 *Autographa precationis* (Guenée)
[Common Looper Moth]

MONA: At least four widely scattered dots are plotted in Virginia (original sources unknown) for this common eastern North American species, including 2–3 in northern Virginia, another apparently corresponding to

the City of Virginia Beach, and 1–2 others in southwestern Virginia (presumably including Giles Co.).
Other published Virginia records: State only (EC78); Augusta (Butler et al., 2001), Bath (Skinner, 1921; CMNH, 3), Fairfax (Steury et al., 2007), Giles (Milne & Milne, 1944), Grayson (SLN 22[3], 2000), Hanover (Ludwig, 2000, 2009), Madison (Manderino et al., 2014), and Rappahannock (Manderino et al., 2014) counties; City of Virginia Beach (Bastian, 2011).
VDCR-DNH records (123 specimens): Accomack, Augusta, Bath, Bedford, Botetourt, Chesterfield, Craig, Dickenson, Fairfax, Fauquier, Floyd, Halifax, Hanover, Henrico, Isle of Wight, Lee, Montgomery, New Kent, Northampton, Nottoway, Prince William, Pulaski, Roanoke, Rockingham, Russell, Scott, Smyth, Stafford, and Wise counties and the cities of Chesapeake and Suffolk.
Other Virginia records: Giles (VPISU), Loudoun (W.R. Grooms collection, 5; VPISU), Madison (UCD, 2), Montgomery (VPISU), and Rockingham (CMNH, 1; K. Richers collection, 7) counties and the cities of Martinsville (VPISU), Norfolk (VPISU) and Virginia Beach (CLMNH, 1).
Photo records: Arlington (BAMONA, BG, iNat), Carroll (W. Cook), Powhatan (J. Reilly), Shenandoah (BAMONA), Spotsylvania (iNat), Tazewell (BAMONA), Warren (BAMONA, BG, iNat), and Westmoreland (iNat) counties and cities of Alexandria (iNat), Radford (BG), and Richmond (BAMONA).
Virginia flight dates: 3 April–22 November
Comments: This species is common and widely distributed in Virginia, probably occurring in every county in the state (Fig. 13).

931204/8923 *Autographa ampla* (Walker)
[Large Looper Moth, Climbing Looper, Broken-Banded Y Moth] (Fig. 15)
NEW STATE RECORD

Published Virginia records: None known.
VDCR-DNH records (5 specimens): Bath Co.: Warm Springs Mountain, 1 km N Ingalls Field Airport, 14 June 1999, J.C. Ludwig (1); Warm Springs Mountain, Bald Knob, 7 July 1999, J.C. Ludwig (3), Page Co.: Shenandoah National Park, Bettys Rock, 29 June 2005, A.C. Chazal and S.M. Roble (SNP, 1).
Other Virginia records: Madison Co., [Shenandoah National Park], Skyland, 1 July 1970, R.A. Belmont (UCD, 1). Montgomery Co., Jefferson National Forest, Rt. 630, 4 July 1983, J.D. Hooper (NMNH, 1). Smyth Co., Walker Mountain, north of Marion, 3650 feet, 18–19 June 1992, D.C. Ferguson (NMNH, 4).
Virginia flight dates: 14 June–7 July
Comments: *Autographa ampla* was not recorded for Virginia by Eichlin & Cunningham (1978) or Lafontaine & Poole (1991), and I have not found any other literature reports for the state. This is a widespread northern species that ranges south in the East to Kentucky and North Carolina, and in the West to Arizona and New Mexico (Lafontaine & Poole, 1991). Both known Kentucky localities are in Harlan County (Covell, 1999), which borders Lee County, VA, the westernmost county in the state. Glaser et al. (unpublished) considered it rare in Maryland, with records limited to the two westernmost counties in that state. Pogue (2005) recorded *A. ampla* from four sites in Great Smoky Mountains National Park near the North Carolina-Tennessee border. Wagner et al. (2011) listed the Georgia mountains as the southern range limit. With the exception of the Montgomery County location (671 m [2200′]), this species is known in Virginia only from the higher mountains (Fig. 10; elevational range 1036–1289 m [3400–4230′]). It is currently placed on the VDCR-DNH Animal Watchlist because of the limited number of Virginia records (Roble, 2016).

931209/8907 *Megalographa biloba* (Stephens)
[Bilobed Looper Moth]

MONA: Up to four widely scattered dots are plotted in Virginia (original sources unknown) for this common New World species. For the purposes of Figure 14, I estimated the corresponding counties for which I lacked other records as Arlington and Smyth counties.
Other published Virginia records: State only (EC78); Hanover Co. (Ludwig, 2000, 2002, 2009); City of Virginia Beach (Bastian, 2011).
VDCR-DNH records (14 specimens): Augusta, Bedford, Dickenson, Floyd, Hanover, Highland, Montgomery, Northampton, and Russell counties and the City of Suffolk.
Other Virginia records: Augusta Co., George Washington National Forest, WVU non-target gypsy moth study, 1995–2001, total of one capture (L. Butler & J. Strazanac, unpub. data). Floyd (S. Felker collection, 3), Giles (VPISU, 1), Lancaster (P. Dennehy collection, 1), Loudoun (W.R. Grooms collection, 1), Montgomery (UK, 1; VPISU, 7), Prince George (MCGL, 1), and Rockingham (CMNH, 1) counties.
Photo records: Powhatan Co. (J. Reilly).
Virginia flight dates: 8 April–15 October
Comments: *Megalographa biloba* is probably more

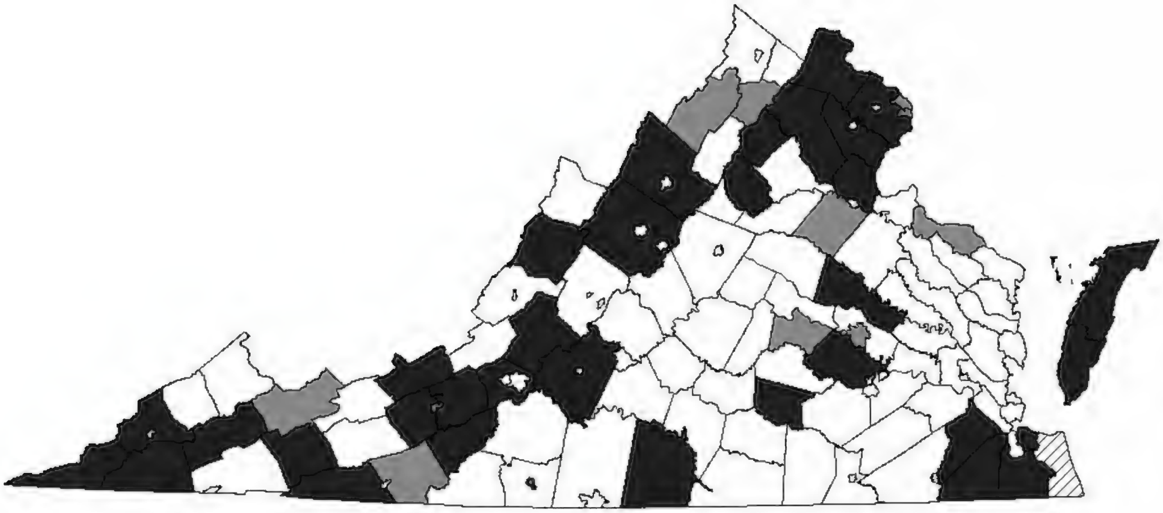

Fig. 13. County and city distribution of *Autographa precationis* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

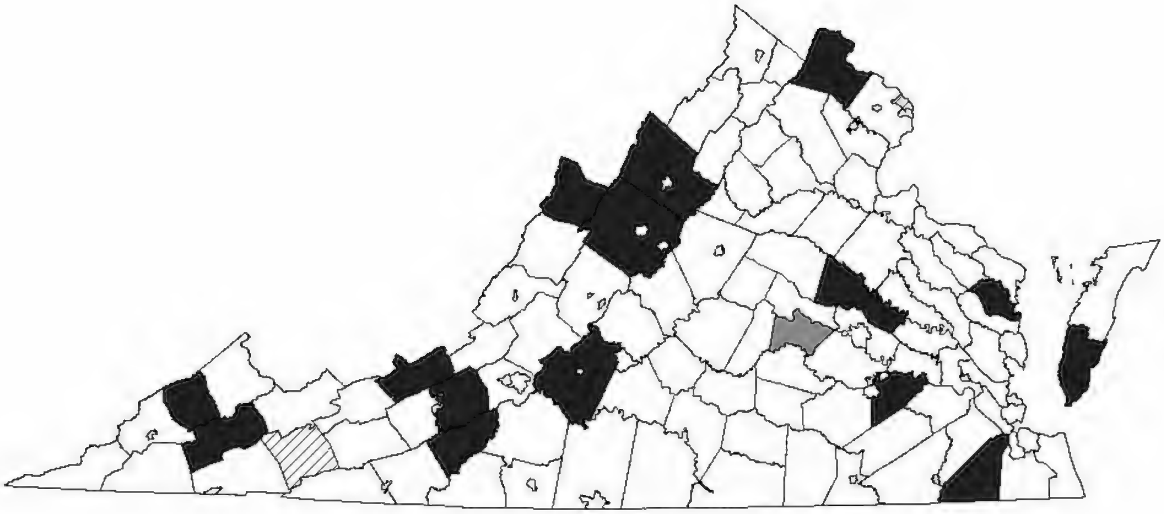

Fig. 14. County and city distribution of *Megalographa biloba* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal hatching = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

common in Virginia than the available records (Fig. 14) suggest. It exhibits migratory behavior, with records from Great Britain suggestive of trans-Atlantic movements. Its native range extends from Canada south to Argentina (Lafontaine & Sullivan, 2009). Areas with freezing winters are recolonized each summer and early fall from more southerly locations (Powell & Opler, 2009). This species was formerly placed in the genus *Autographa* (Covell, 1984; Wagner et al., 2011).

931225/8939 *Syngrapha alias* (Ottolengui)
[Hooked Silvery Y Moth, Spruce Looper] (Fig. 15)
NEW STATE RECORD

Published Virginia records: None known.
VDCR-DNH records (14 specimens): Grayson Co.: Jefferson National Forest, Whitetop Mountain, 30 June 2010, S.M. Roble and P. Bedell (1); same data but S.M. Roble (2); same site but 11 July 2012, S.M. Roble (1); same site but 22–23 July 2014, S.M. Roble (2); Grayson Highlands State Park, Haw Orchard Mountain (near Cox Visitor Center), 30 June 2011, S.M. Roble (5); Grayson Highlands State Park, Massie Gap, Wilburn Ridge, 23 July 2014, S.M. Roble (1). Highland Co.: George Washington National Forest, Bearwallow Run, 4 August 2011, S.M. Roble (1); same data but Newman Run, 4 August 2016 (1).
Virginia flight dates: 30 June–4 August
Comments: My recent collections of this species in the highest portions of the Blue Ridge Mountains in southwestern Virginia near the North Carolina border are the first known records of this species in the state. I have also taken two specimens near the West Virginia border in Highland County. All sites are dominated by red spruce (*Picea rubens* Sargent), the presumed larval hostplant in the state. The elevational range of these sites is 1067–1676 m (3500–5500′). Due to the limited number of Virginia records and its restricted habitat, *S. alias* is currently placed on the VDCR-DNH Rare Animal List (Roble, 2016). This is potentially the plusiinae most vulnerable to the effects of global climate warming because of its relictual, high elevation distribution in the southern Appalachians.

The range map in Lafontaine & Poole (1991) shows a potentially disjunct population in the mountains of western North Carolina, the next nearest record being in New Jersey. My collections (Fig. 16), plus records from West Virginia (Albu & Metzler, 2004; S. Johnson, unpub. data), partially fill in this gap. Pogue (2005) reported the collection of eight specimens of *S. alias* from the higher mountains (1603–1829 m) of North Carolina and Tennessee in Great Smoky Mountains National Park at its southern range limit.

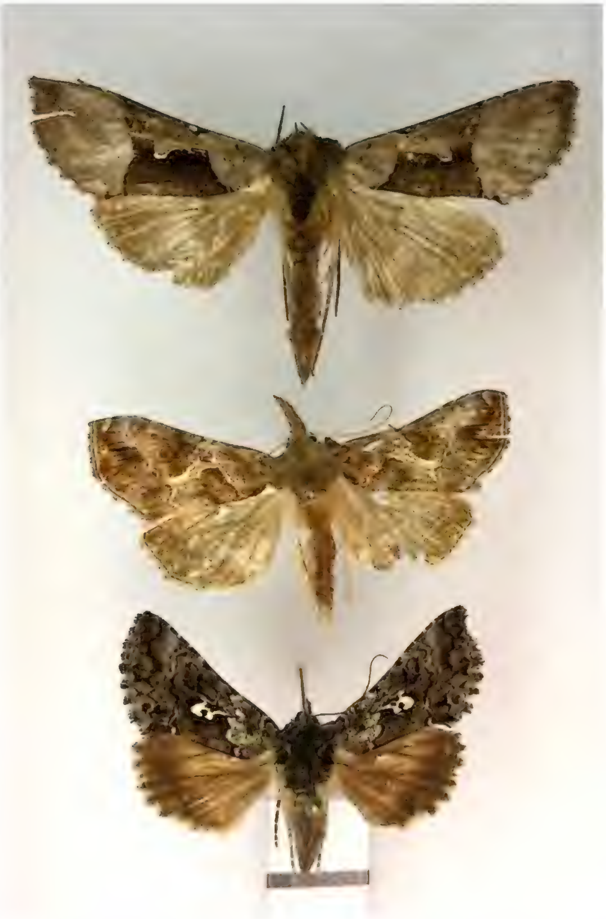

Fig. 15. (top to bottom; scale bar 1 cm): *Autographa ampla* (Bath Co., VA, 7 July 1999); *Polychrysia morigera* (Lee Co., VA; 22 May 2000); *Syngrapha alias* (Grayson Co., VA, 30 June 2011).

931127/8942 *Syngrapha rectangula* (W. Kirby)
[Salt-and-pepper Looper Moth]

Published Virginia records: Augusta Co., George Washington National Forest (Butler et al., 2001 [plus subsequent surveys, L. Butler & J. Strazanac, unpub. data; 2 of 3 captured specimens were retained: 31 July 1995 (VDCR-DNH), 7 August 1995 (WVU)]). Giles Co., Jefferson National Forest, White Rocks campground, 20–23 August 1991, G.D. Willis (1; SS-TLS, 1992); Mountain Lake Biological Station (MONA plate 3, fig. 41 - photo of NMNH specimen collected on 7 July 1975 by J. Jaworski).
VDCR-DNH records (2 specimens): Highland Co.: near cabin off Rt. 642 at VA-WV state line, 4 August 2011, S.M. Roble (1); 2 km S Mustoe, 25 August 2016, S.M. Roble (1).
Other Virginia records: None known.

Virginia flight dates: 7 July–25 August
Comments: This species inhabits the mountains of western Virginia (Fig. 16), but apparently occurs at lower elevations than *S. alias* and not always in areas where red spruce is present. Perhaps some populations of *S. rectangula* in Virginia utilize eastern white pine (*Pinus strobus* L.) or eastern hemlock (*Tsuga canadensis* [L.]) as their hostplant.

Covell (1984) stated that *S. rectangula* is active by day, at dusk, and at night, and cited the range as Newfoundland to Pennsylvania, west through Canada, and south to Minnesota. The range map in Lafontaine & Poole (1991) includes only three records of this boreal species south of Pennsylvania, including one in Virginia (presumably Mountain Lake, Giles Co.) and two in western North Carolina. Butler & Strazanac (2014) listed one record for each of three counties in West Virginia, and Pogue (2005) recorded *S. rectangula* from four sites in North Carolina and Tennessee in Great Smoky Mountains National Park at its southern range limit. Due to the limited number of Virginia records, *S. rectangula* is currently placed on the VDCR-DNH Rare Animal List (Roble, 2016).

931234/8924 *Anagrapha falcifera* (W. Kirby)
[Celery Looper Moth]

MONA: Between two and four dots appear to be plotted in Virginia (original sources unknown) for this common North American species. For the purposes of Figure 17, I estimate that Arlington was the only corresponding county for which I lacked records from other sources.
Other published Virginia records: State only (EC78); Augusta (Butler et al., 2001), Bath (Skinner, 1921; CMNH, 4), Fairfax (Steury et al., 2007), Hanover (Ludwig, 2000, 2009), Madison (Manderino et al., 2014), Tazewell (Stein, 1993), and Wise (Holl, 1996) counties; City of Virginia Beach (Bastian, 2011).
VDCR-DNH records (61 specimens): Accomack, Alleghany, Bath, Botetourt, Dinwiddie, Fairfax, Fauquier, Floyd, Frederick, Grayson, Halifax, Hanover, Isle of Wight, Madison, Northampton, Page, Prince William, Pulaski, Richmond, and Tazewell counties and the City of Virginia Beach.
Other Virginia records: Floyd (S. Felker collection, 2), Giles (VPISU, 4), Loudoun (W.R. Grooms collection, 7; R. Lyon collection, 1), Montgomery (UK, 3; VPISU, 37), and Rockingham (CMNH, 2; K. Richers collection, 3) counties and the cities of Newport News (VPISU, 1), Roanoke (VPISU, 2), and Suffolk (VPISU, 3).
Photo records: Carroll (W. Cook), Chesterfield (BAMONA), Mecklenburg (iNat), Powhatan (J. Reilly), and Westmoreland (iNat) counties; City of Richmond (BAMONA).
Virginia flight dates: 2 April–5 November
Comments: This species is common and widely distributed in Virginia (Fig. 17). Powell & Opler (2009) characterized it as "very adaptable and invasive," occurring in weedy or cultivated habitats as well as natural habitats.

931236/8950 *Plusia putnami* Grote
[Putnam's Looper Moth]

Published Virginia records: State only (Eichlin & Cunningham, 1978; Covell, 1984).
VDCR-DNH records: None.
Other Virginia records: None known.
Virginia flight dates: No data.
Comments: This Holarctic species was recorded (without details) for Virginia by Eichlin & Cunningham (1978) and Covell (1984; latter perhaps based on the former), but not Lafontaine & Poole (1991). My museum searches failed to locate any Virginia specimens of *P. putnami*, but NMNH has a century old specimen from West Virginia collected by renowned lepidopterist W.H. Edwards (1822–1909; see Calhoun, 2014) which lacks a specific locality and date (but presumably was collected post-1863, the year West Virginia gained statehood) on the label. Given the lack of any modern records from Virginia and neighboring states, the validity of the report by Eichlin & Cunningham (1978) should be considered dubious until a voucher specimen from the state has been located or collected anew. If it is indeed a member of the Virginia fauna, this would be the southernmost known record for *P. putnami* in the East according to the range map in Lafontaine & Poole (1991) and all other sources that I have checked.

DISCUSSION

Twenty-five species of the noctuid moth subfamily Plusiinae have been documented or reported from Virginia. Wagner (2005) stated that there are 50 Eastern species of plusiines, thus half of these are recorded from Virginia. The Virginia faunal tally compares favorably to the totals for North Carolina and Ohio, and exceeds the figures for Kentucky, West Virginia, and Maryland (Table 1). Pogue (2005) recorded 17 plusiines during intensive sampling of Great Smoky Mountains National Park. He also cited higher species diversity totals for more northern states such as Maine (31), New York (30), and New Hampshire (26) (Pogue, 2005).

The following five additional species of Plusiine may also occur in Virginia, with the species of *Syngrapha* perhaps having the greatest potential:

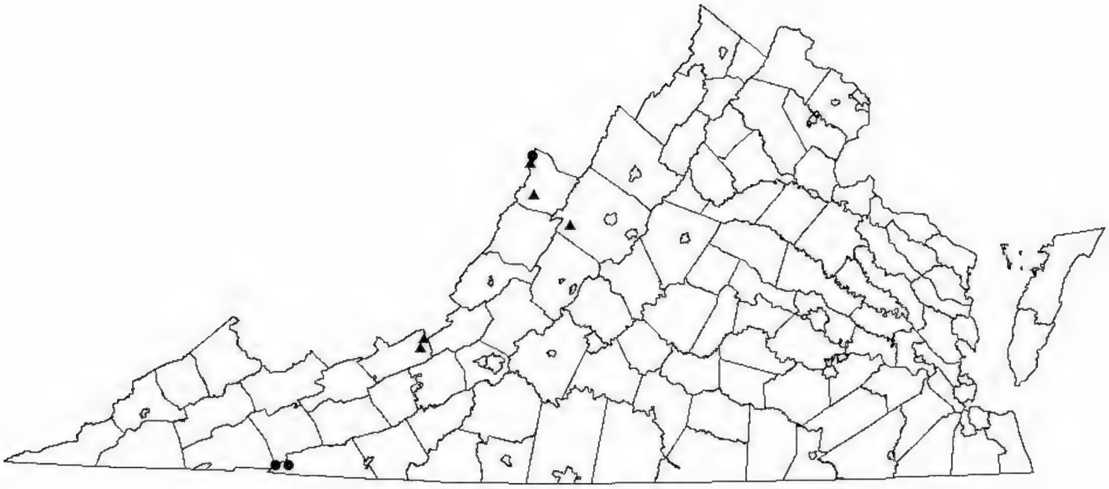

Fig. 16. Distribution of *Syngrapha alias* (circles) and *S. rectangula* (triangles) in Virginia (voucher specimens). Some symbols represent multiple proximate collecting sites.

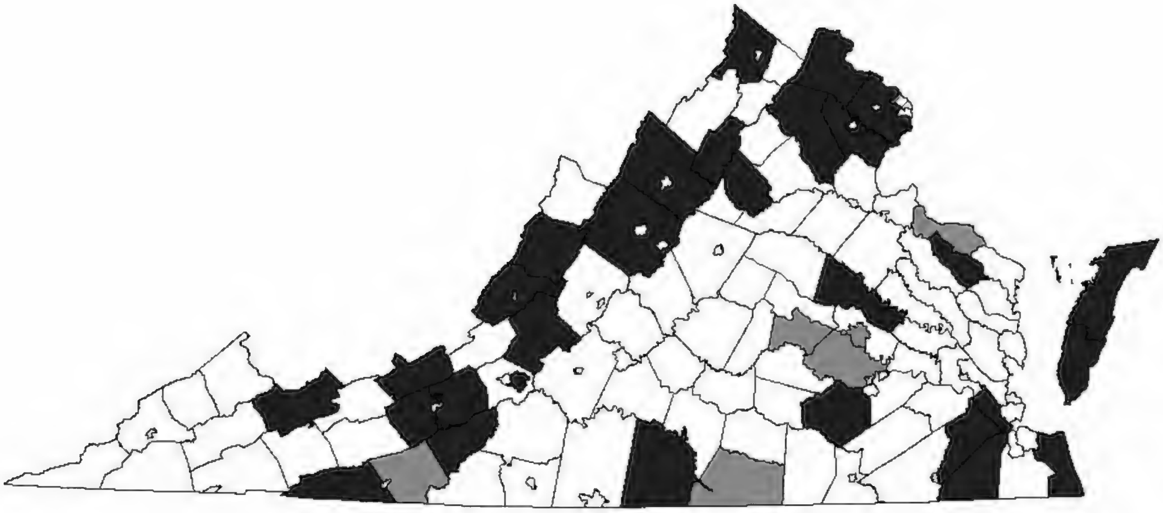

Fig. 17. County and city distribution of *Anagrapha falcifera* in Virginia (dark shading = voucher specimens, light shading = photographs, diagonal shading = estimated county or city locations of points mapped by Lafontaine & Poole [1991]).

Table 1. Comparative Plusiinae faunas of Virginia and neighboring states plus Ohio.

Species	VA	MD	NC	KY	WV	OH
Abrostola ovalis	x	x	x	x	x	x
A. urentis	x	x	x	x	x	x
Mouralia tinctoides	-	-	-	x	-	-
Argyrogramma verruca	x	x	x	x	x	x
Enigmogramma basigera	x	x	x	x	-	x
Trichoplusia ni	x	x	x	x	x	x
Ctenoplusia oxygramma	x	x	x	x	x	x
Chrysodeixis includens	x	x	x	x	x	x
Autoplusia egena	-	-	x	-	-	-
Rachiplusia ou	x	x	x	x	-	x
Diachrysia aereoides	x	x	x	x	x	x
D. balluca	x	x	x	x	x	x
Allagrapha aerea	x	x	x	x	x	x
Pseudeva purpurigera	x	x	x	x	x	x
Polychrysia morigera	x	-	x	x	x	x
Chrysanympha formosa	x	x	x	x	x	x
Eosphoropteryx thyatyroides	x	x	x	x	x	x
Exyra fax	x	-	x	-	-	-
E. semicrocea	x	-	x	-	-	-
E. ridingsii	x	-	x	-	-	-
Megalographa biloba	x	x	x	x	x	x
*Autographa precationis**	x	x	x	x	x	x
A. pseudogamma	-	-	-	x	-	-
A. ampla	x	x	x	x	x	x
Anagrapha falcifera	x	x	x	x	x	x
Syngrapha octoscripta	-	-	-	-	-	x
S. epigaea	-	-	-	-	x	x
S. alias	x	-	x	-	x	-
S. abstrusa	-	x(?)	-	-	-	x
S. rectangula	x	-	x	-	x	x
*Plusia putnami***	x	-	-	-	x	-
P. contexta	-	x	-	-	x	x
Total species	25	20	25	21	22	24

*One specimen of *Autographa californica* was collected in Maryland far out of range (Glaser et al., unpublished; USNM).

** *Plusia venusta* was collected in the 1800s in Washington, DC (Lafontaine & Poole, 1991).

Data sources: Lafontaine & Poole (1991); Rings et al. (1992); Covell (1999); Albu & Metzler (2004); Pogue (2005); Butler & Strazanac (2014); Covell et al. (2018); Glaser et al., unpublished; Line (Moths of Maryland); Maryland Biodiversity Project; North Carolina Biodiversity Project; Moth Photographers Group; BugGuide; USNM; this paper.

Autoplusia egena (Guenée) [Bean-lead Skeletonizer Moth] is a southern species that ranges north to southwestern North Carolina, with a vagrant record from near Detroit, Michigan (Lafontaine & Poole, 1991).

Syngrapha abstrusa Eichlin [Abstruse Looper Moth] is a northern, conifer-feeding species that ranges south as far as New Jersey and Ohio in the East (Lafontaine & Poole, 1991). A purported photo record from eastern Maryland (Line [Moths of Maryland website]; Maryland Biodiversity Project) is best treated as unconfirmed because differentiation of this species from *S. alias* requires genitalic dissection. Pogue (2005) did not document *S. abstrusa* in the Smokies. This species should be sought in the higher mountains of western Virginia.

Syngrapha epigaea (Grote) [Epigaea Looper Moth, Inscribed Looper, Pirate Looper] is another northern, conifer-feeding species. It reportedly ranges south to northern Ohio and central Pennsylvania in the East (Lafontaine & Poole, 1991). However, within the past decade this species has been recorded much farther south at Spruce Knob, Pendleton County, West Virginia, the highest point in that state (1482 m [4863 ft]) on at least five occasions: 3 July 2010, P. Dennehy (P. Dennehy collection, 1; photograph of specimen at BugGuide #1210658); 9 July 2011, J.D. Hooper (NMNH, 1); 10–12 July 2011 and 2–7 July 2012, S. Johnson (S. Johnson collection, 2); 11 July 2014, K. Lebo (photo; BAMONA #102590). Butler & Strazanac (2014) did not include *S. epigaea* in their list of West Virginia moths in the WVU collection. This species may occur in the red spruce forests of northwestern Highland County, Virginia, which are less than 15 km southwest of Spruce Knob, but at an elevation about 300 m (1000 feet) lower.

Plusia contexta Grote [Connected Looper Moth] is the most commonly collected species of *Plusia* in the East, ranging south to New Jersey, Pennsylvania, and Ohio (Lafontaine & Poole, 1991). Butler & Strazanac (2014) reported this species from Morgantown and Natrium, West Virginia. It has also been collected in two Maryland counties (Glaser et al., unpublished; Maryland Biodiversity Project; specimens in NMNH).

Plusia venusta Walker [White-streaked Looper Moth] has a more boreal distribution than *P. contexta*, but surprisingly, its southernmost known locality in the East is the District of Columbia (Lafontaine & Poole, 1991). This nearly century-and-a-half old record is mentioned in the original description of *P. striatella* Grote, a junior synonym (Grote, 1873). Eichlin & Cunningham (1978) recorded *P. venusta* from Maryland, but there are no records in Glaser et al. (unpublished) or the Maryland Biodiversity Project database, thus casting doubt on the validity of their report. Lafontaine & Poole (1991) remarked that *P. venusta* is the most rarely collected of the three Eastern members of this genus.

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David Wagner, Dale Schweitzer, and Christopher Heckscher collectively made me aware of Jones' (1928–1939) unpublished manuscript on Delmarva Lepidoptera and generously provided a photocopy of it. Dale also identified some of the VDCR-DNH specimens cited above. The late John Glaser provided a copy of his unpublished manuscript (Glaser et al.) on the moth fauna of Maryland. John Strazanac shared a summary of the unpublished results of the long-term (L. Butler & J. Strazanac, 1995–2001) WVU non-target gypsy moth study conducted on the George Washington National Forest in Virginia and the Monongahela National Forest in West Virginia (few voucher specimens were retained; only data from 1995–1996 were summarized in Butler et al., 2001). John Peacock and Laura Neale shared the results of the first year of a similar unpublished study (1991–1993) conducted in Rockbridge County, Virginia.

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Distribution, Hybridization, and Taxonomic Status of Two-lined Salamanders (*Eurycea bislineata* complex) in Virginia and West Virginia

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ABSTRACT

We used three diagnostic protein markers to examine salamanders of the *Eurycea bislineata* complex at 80 localities in Virginia and West Virginia. Two groups were strongly differentiated and met at a narrow contact zone. Rare hybridization was observed as well as limited introgression up to 5 km north and 10 km south of the contact zone. At the contact zone, 1% F_1, 2% F_2, 32% backcross, and 66% parental genotypes were observed. This pattern of parapatric distribution with limited hybridization and introgression argues for the recognition of *Eurycea bislineata* and *E. cirrigera* as separate species.

Keywords: *Eurycea bislineata* complex, electrophoresis, hybridization, speciation.

INTRODUCTION

A lively debate has surrounded the systematics of the *Eurycea bislineata* complex (*E. bislineata*, *E. cirrigera*, and *E. wilderae*) over the past several decades (Pauley & Watson, 2005; Sever, 2005). In a broadscale study using protein electrophoresis of 22 proteins and 66 populations, Jacobs (1987) elevated each of the previously recognized subspecies to full specific status. Petranka (1998), however, recommended the recognition of subspecies until such time as contact zones were examined and the degree of gene exchange occurring between genetic subgroups was quantified. Kozak & Montanucci (2001) subsequently studied the contact zone between *E. cirrigera* and *E. wilderae* in the Carolinas and found evidence of a parapatric distribution with very little gene exchange between the two groups. Camp et al. (2000) found *E. cirrigera* and *E. wilderae* together in a zone of sympatry approximately 15 km wide in Georgia. Guttman & Karlin (1986), in a paper described by Petranka (1998) as the strongest evidence that *E. bislineata* is a semispecies or superspecies complex, examined the boundary between *E. bislineata* and *E. cirrigera* in Ohio and Indiana. They found evidence of a narrow hybrid zone where only occasional hybrids and backcross progeny occurred.

Several authors (Guttman & Karlin, 1986; Jacobs, 1987; Petranka, 1998; Kozak & Montanucci, 2001) commented on the need for additional genetic analyses of contact zones between each of the species pairs to provide further evidence for a taxonomy that accurately reflects the evolutionary history of the *E. bislineata* complex. We present a fine-scaled genetic analysis of the contact zone between *E. bislineata* and *E. cirrigera* in Virginia and West Virginia. This is the first genetic analysis of species boundaries in West Virginia (Sever, 2005) and a detailed analysis of the southern end of the same contact zone studied by Guttman & Karlin (1986). We include data on hybridization and introgression between these two taxa. Our data confirm the conclusions of Guttman & Karlin (1986) that limited hybridization occurs along a narrow and well-defined contact zone, and these taxa are sufficiently distinct to warrant specific status.

MATERIALS AND METHODS

We collected two-lined salamanders from throughout West Virginia and Virginia from 1987–1995. However, more extensive collections were made in central Virginia, both to delineate the location of the contact zone, and to determine its composition (Appendix 1). Animals were transported to the lab where they were sacrificed in 1,1,1-Trichloro-2-methyl-2-propanol. Whole body homogenates were prepared by grinding in a buffer composed of .01M Tris-HCl, .25M Sucrose, .001M EDTA, pH = 7.0. Homogenates were individually centrifuged at 10,000 x G for 15 min and frozen at -80 ºC until electrophoresis, which was usually within one month of sample preparation.

We used diagnostic electrophoretic loci described by Guttman & Karlin (1986) and Jacobs (1987) to identify salamanders. Allozymes are encoded by nuclear genes which exhibit codominant inheritance. They can be used to identify species-specific genotypes, as well as various types of hybrids. The designation of genetic loci and alleles follows that of Jacobs (1987). Glutamic Oxaloacetic Transaminase (GOT-1, 2.6.1.1) was resolved using the lithium hydroxide pH 8.1 buffer of Selander et al. (1971). Six-Phosphogluconate Dehydrogenase (6-PGDH, 1.1.1.44) and Alanyl-leucyl Peptidase (PEP, 3.4.11) were resolved using the tris-citrate pH 8.0 buffer of Selander et al. (1971). We used standard starch-gel electrophoretic techniques with 12.5% hydrolyzed potato starch from Starch-Art®.

We did not use several of the diagnostic markers used by Guttman & Karlin (1986) and Jacobs (1987). GOT-2/AAT-2 was temperature labile and could not be consistently scored for all individuals from all populations and was therefore omitted from further consideration. Although we found variation at these loci, Malic Enzyme and Lactate Dehydrogenase (LDH-1) were not diagnostic in West Virginia and Virginia when compared with the other three markers. Jacobs (1987) also did not use LDH-1.

At each locus, electromorphs with the same mobility were considered homologous, and those with different mobilities were recorded as different alleles. Alleles with the greatest anodal mobility were designated as “a” and the others were assigned “b”, “c”, “d”, or “e” in order of decreasing mobility from the gel origin. We established allelic homologies by simultaneously running representative samples from several populations on the same gel.

“Pure” species genotypes were those with electromorphs characteristic of only one of the species. Some individuals were heterozygous for all three of the protein markers and exhibited electromorphs characteristic of both parental species. These individuals could have been the result of a large variety of gametic combinations. However, the simplest and thus most probable interpretation, is that they resulted from an interspecific mating of “pure” species genotypes. We considered them F1 hybrids and, by inference, characterized a variety of other genotypes that resulted from interbreeding and backcrossing (Guttman & Karlin, 1986). F_2 hybrids were homozygous for one species at one or two markers and homozygous for the other species at the remaining markers. Backcross genotypes (backcross to *E. bislineata* or *E. cirrigera* possible) were heterozygous for one or two markers (but not all three) and homozygous for one of the parental species at the remaining markers.

RESULTS AND DISCUSSION

Allele frequencies for each of the three marker loci demonstrate that certain alleles are fixed or nearly so in each population sampled. The allelomorphs characterizing populations 1–33 differ from those in populations 36–80. Furthermore, there is an abrupt discontinuity in the frequency of these three diagnostic enzymes across a narrow geographic area. Populations 1–33 taken from the north and east portions of our study area, are characterized by the following *E. bislineata* genotypes (Guttman & Karlin, 1986): 6-PGDH^{c,d}; GOT-1^{c,d}; PEP^{c} (Appendix 1). Conversely, populations 36–80 taken from the south and west portions of our study area, are characterized by the following *E. cirrigera* genotypes (Guttman & Karlin, 1986): 6-PGDH^{a,b}; GOT-1^{a,b}; PEP^{a,b,d,e} (Appendix 1). Populations 34 and 35 contain both *E. bislineata* and *E. cirrigera* genotypes as well as F_1 and other hybrid genotypes (Appendix 1). Our *E. bislineata* populations correspond very closely to the Virginia/West Virginia portions of lineages A and B (forming a single clade on phylogram) from a phylogeographic study of *Eurycea* using mtDNA haplotypes (Kozak et al., 2006), whereas our *E. cirrigera* populations correspond with the Virginia/West Virginia portions of lineage E from that same study.

Including allelomorphic data from southeastern Ohio presented in Guttman & Karlin (1986), the contact zone between *E. bislineata* and *E. cirrigera* can be traced in general detail. In Ohio, *E. bislineata* is found north of central Ohio. In West Virginia, *E. bislineata* occurs in the east to approximately Tucker, Randolph, Webster, and Pocahontas counties. In Virginia, *E. bislineata* occurs north of an east/west line through the boundary between Greene and Albemarle counties, extending eastward to Stafford County (Fig. 1).

In Ohio, the contact zone follows the Wisconsin glacial boundary with *E. cirrigera* occurring along the boundary or to the south in unglaciated regions and *E. bislineata* to the north of these areas (Guttman & Karlin, 1986). The West Virginia distribution of *E. cirrigera* corresponds with the Allegheny Plateau physiographic province, whereas the distribution of *E. bislineata* corresponds to the Allegheny Mountain and Ridge and Valley provinces (Green & Pauley, 1987). In Virginia, the distribution of these species tends to cut across physiographic provinces rather than follow them. The distribution of *E. bislineata* corresponds roughly with the Shenandoah River drainage, following the northern

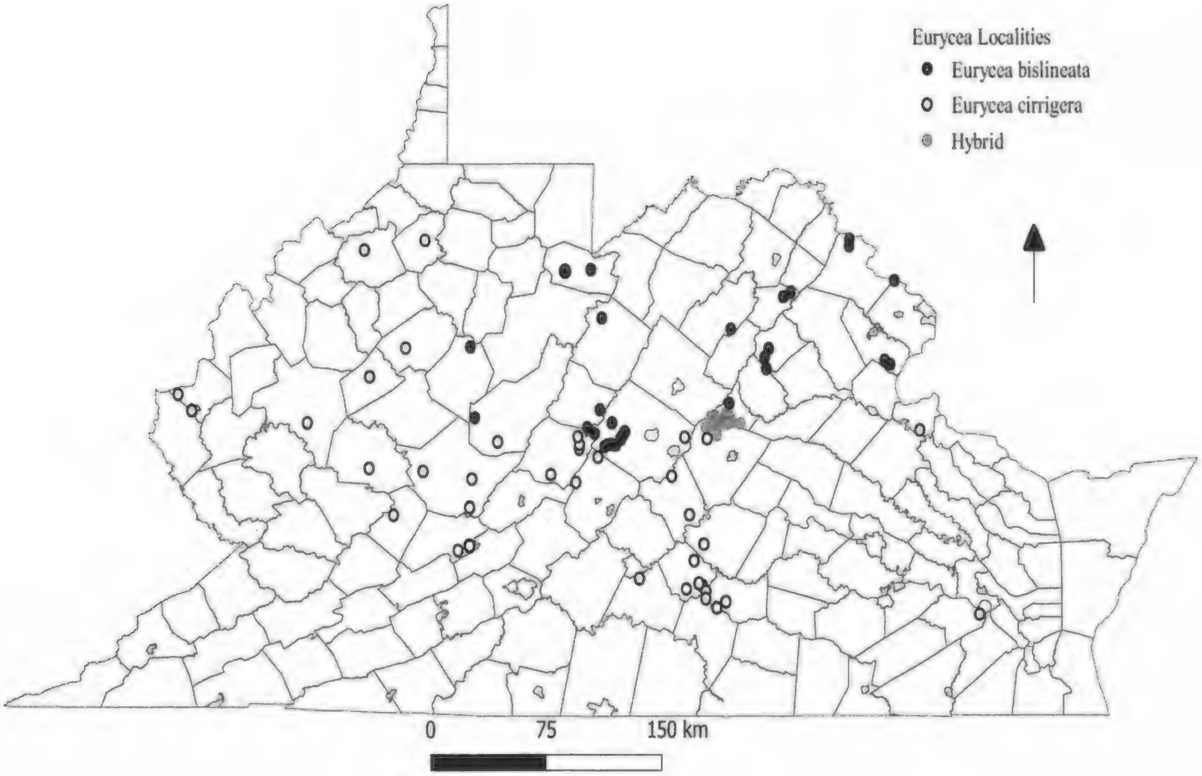

Fig. 1. Distribution of 80 populations of *Eurycea* sampled in Virginia and West Virginia. Black circles represent *E. bislineata*, white circles represent *E. cirrigera*, and gray circles represent a contact zone in Central Virginia including sympatric populations with F_1 hybrids (populations 34-35), as well as populations with F_2 hybrids and/or other backcross progeny (18-21, 38-45). See Appendix 1 for detailed locality information.

Allegheny, Shenandoah, and Blue Ridge mountains down to approximately Interstate Highway 64. *Eurycea cirrigera* occurs within the lower Potomac and James River drainages, and all points south and west within Virginia (Fig. 1).

The identity and status of two-lined salamanders on Virginia's Eastern Shore has long baffled state herpetologists. The Virginia Department of Game and Inland Fisheries (2016) reports "known" and "confirmed" occurrences of *E. cirrigera* from both Accomack and Northampton counties. There are also electrophoretically verified occurrences of *E. cirrigera* from Worcester County, the southernmost county on Maryland's Eastern Shore, southward onto Virginia's Eastern Shore (Gronert, 2018). In fact, Gronert (2018) cites unpublished data from Paul Sattler's lab (collected using the precise methods described in this paper) to verify these localities. Gronert (2018) also comments that the *E. cirrigera* from Worcester County are the northernmost records submitted to the Maryland Amphibian and Reptile Atlas. Given these data, and the fact that Gronert (2018) considers all two-lined salamanders north of Worcester County to be *E. bislineata*, the contact zone between *E. bislineata* and *E. cirrigera* probably occurs on Maryland's Eastern Shore, somewhere between Worcester and Caroline counties. The location of this contact zone is directly east, across the Chesapeake Bay, from the contact zone we report on Virginia's mainland in Stafford County (see Fig. 1), suggesting the current distribution was established sometime before the formation of the Chesapeake Bay. Kozak et al. (2006) suggest that present distributions in the *Eurycea bislineata* complex are more highly correlated with historical river drainage patterns than contemporary ones. Drainage patterns have changed over geological time but the geographic ranges of semiaquatic salamander species, such as *Eurycea,* have likely remained static or nearly so (Kozak et al., 2006). Our distribution data tend to confirm this concept.

Based on analyses of distributional and ecological patterns, several authors have suggested that *E. cirrigera* generally occurs in warmer and/or more southern streams that have a lowland character, whereas *E. bislineata* can

Table 1. Species composition (number of sampled individuals) of *Eurycea* populations in central Virginia contact zone, in an approximate northwest to southeast order.

Population	***E. bislineata***	**Backcross to *E. bislineata***	**F_1 Hybrid**	**Backcross to *E. cirrigera***	***E. cirrigera***	**F_2 Hybrid**
22	29					
21	14	6				
20	9	3				
19	15	7				
18	15	6				
34	10	13	1	3	2	1
35	2	1	1	6	3	
38				1	1	1
39					2	
40						1
41				9	11	1
42				1		
43				3	4	
44					4	
45				4	10	
46					3	
Total	**94**	**36**	**2**	**28**	**40**	**4**
% of Total	**46.1**	**17.6**	**1.0**	**13.7**	**19.6**	**2.0**

generally be found in colder and/or more northern streams (Guttman & Karlin, 1986; Camp et al., 2000; Kozak & Montanucci, 2001). These generalizations appear to hold true, at least in part, for Virginia and West Virginia as well. Some ecological literature suggests that *E. bislineata* is better adapted for survival in cold water streams as compared to *E. cirrigera* (Martof, 1955; Allen, 1963; Brooks & Sassaman, 1965). Additional ecological studies are necessary in areas of sympatry to determine how reproductive isolation is maintained between these two species (Sever, 2005).

The contact zone between *E. bislineata* and *E. cirrigera* is best described as parapatric with areas of local sympatry. The localities in central Virginia, which were examined in greater detail, are included in Table 1 in an approximate northwest-southeast order. Adjacent localities are separated by approximately 2–5 km. *Eurycea bislineata* and *E. cirrigera* maintained distinct gene pools in the contact zone. Only two localities (34 and 35) contained both parental genotypes and F_1 hybrids. As Guttman & Karlin (1986) reported for Ohio, even within sympatry only one species predominated at any locality (Table 1). This strict parapatric distribution severely limits contact and potential for hybridization. Our detailed analysis shows that only 2 of 204 (<1%) salamanders sampled from within the contact zone are F_1 hybrids (Table 1).

Like Guttman & Karlin (1986), our study found that F_1 hybrids are produced at a much lower frequency than subsequent backcross genotypes. In Ohio, 1.5% F_1 hybrids, 7.5% F_2 hybrids, 36% backcross, and 55% parental genotypes were reported in areas of sympatry. In Virginia, the corresponding values were 1%, 2%, 32%, and 66% (Table 1). Although the formation of F_1 hybrids is relatively rare, backcrosses are 25–30 times more frequent. The presence of F_2 hybrids and backcross genotypes indicates that F_1 hybrids may be viable and fertile. The four genotypes defined as F_2 hybrids in Table 1 are homozygous for an *E. bislineata* electromorph at one marker and homozygous *E. cirrigera* for at least one other marker. These genotypes most likely represent advanced generation backcross genotypes, considering the low number of F_1 hybrids and the small potential for F_1 x F_1 crosses in these populations.

The area of sympatry within which both genotypes are found is no wider than several kilometers and probably much closer to several hundred meters. Guttman & Karlin (1986) reported that the northern end of the contact zone was no more than 15 km wide and that introgression occurred primarily from *E. bislineata* to *E. cirrigera*. In central Virginia, introgression was detected up to 5 km north and 10 km south of the contact zone. There are slightly more (18 vs. 14%) backcross genotypes with *E. bislineata* than *E. cirrigera*. However, *E. bislineata* is also more than twice as abundant (46 vs. 20%) as *E. cirrigera* in these same populations (Table 1). Therefore, while introgression is bidirectional, there is a higher proportion of *E. bislineata* alleles passed to *E. cirrigera* than in the opposite direction.

Our sample sizes are too small to test for Hardy-Weinberg equilibrium at the marker loci in these populations. Guttman & Karlin (1986) found equilibrium at these loci in backcrossed populations where only one parental species was present and at least some loci not at equilibrium when both parental species were present. When both parental genotypes were present, there was assortative mating within genotypes. When only one species was present, the hybrid and backcross genotypes exhibited random mating. Backcross genotypes had the same ability to obtain mates as parental genotypes.

This pattern of limited hybridization, coupled with Genetic Distance estimates of 0.346 (Guttman & Karlin, 1986) and 0.45 (Jacobs, 1987), provide evidence that *E. bislineata* and *E. cirrigera* maintain distinct gene pools. The picture is one of two species coming together with a parapatric distribution and maintaining genetic identity with only occasional hybridization. There is some introgression, but it is restricted to a narrow contact zone. Introgression may be limited by the low vagility of the salamanders, genetic incompatibility with a foreign genome, or natural selection eliminating foreign alleles not adapted to the local environment. Using the criteria of Mayr (1963) for the biological species concept, we agree with Guttman & Karlin (1986) and Jacobs (1987) that two species with separate gene pools are represented. The available evidence, derived from an analysis of the contact zone in both the northern and southern portions of the range, supports Jacobs' (1986) elevation of *E. bislineata* and *E. cirrigera* to full specific status.

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Appendix 1. Localities, sample sizes (N), and allelic frequencies (a-e) of three diagnostic proteins for 80 populations (Pop.) of the *Eurycea bislineata* complex from Virginia and West Virginia.

Pop.	N	Locality	6-PGDH				GOT-1				PEP				
			a	b	c	d	a	b	c	d	a	b	c	d	e
1	2	Gentle Falls Trail, Blackwater Falls State Park, near Davis, Tucker Co., WV (39° 06' 43" N, 79° 29' 44" W)			1.0				1.0				1.0		
2	1	Watershed 13, Fernow Experimental Forest, near Parsons, Tucker Co., WV (39° 05' 27" N, 79° 41' 11" W)			1.0				1.0				1.0		
3	3	South of Onego, US Rt. 33, Mexico Hollow below Lower Timber Ridge Rd., Pendleton Co., WV (38° 50' 04" N, 79° 25' 01" W)			1.0				1.0				1.0		
4	1	Laurel Fork River at Rt. 10, Holly River State Park, Webster Co., WV (38° 39' 58" N, 80° 21' 17" W)			1.0				1.0				1.0		
5	1	Cranberry Glades Backcountry, near North Fork of Cranberry River, Pocahontas Co., WV (38° 15' 35" N, 80° 19' 19" W)			1.0				1.0						
6	9	Unnamed tributary of Shaws Fork of Cowpasture River at Co. Rt. 616, 2.5 km S US Rt. 250, at FS 395.2, Highland Co., VA (38° 18' 22" N, 79° 25' 48" W)			1.0				1.0				1.0		
7	1	Unnamed tributary to Cowpasture River at FS 394, 13 km E Co. Rt. 627, Bath Co., VA (38° 12' 09" N, 79° 31' 13" W)			1.0								1.0		
8	13	Jerkemtight Creek at Hamilton Branch of Calfpasture River on FS 399, 1.1 km W Co. Rt. 629, Augusta Co., VA (38° 10' 08" N, 79° 27' 58" W)		.04	.96				.79	.21		.19	.69	.12	
9	10	West Dry Branch of Calfpasture River at Co. Rt. 688, 7.4 km E Co. Rt. 629, Augusta Co., VA (38° 13' 49" N, 79° 20' 41" W)		.17	.83				.89	.11			1.0		
10	2	Buffalo Branch, 2.25 km S Buffalo Gap on VA Rt. 42, Augusta Co., VA (38° 10' 44" N, 79° 15' 11" W)			1.0				.5	.5			1.0		
11	16	Buffalo Branch, 4.3 km S Buffalo Gap on VA Rt. 42, Augusta, Co., VA (38° 09' 53" N, 79° 15' 51" W)		.03	.97				.63	.37		.13	.87		
12	6	Little Calfpasture River, 8 km S Buffalo Gap on VA Rt. 42, Augusta Co., VA (38° 08' 51" N, 79° 16' 42" W)			1.0				.6	.4			1.0		

Appendix 1 (continued).

Pop.	N	Locality	6-PGDH				GOT-1				PEP				
			a	b	c	d	a	b	c	d	a	b	c	d	e
13	14	Little Calfpasture River, 10.5 km S Buffalo Gap on VA Rt. 42, Augusta Co., VA (38° 08’ 03” N, 79° 17’ 01” W)			.95	.05			.63	.37			.92	.08	
14	13	Smith Creek at Co. Rt. 601, 0.75 km S VA Rt. 42 at Augusta Springs, Augusta Co., VA (38° 06’ 05” N, 79° 19’ 05” W)			1.0				.69	.31			1.0		
15	2	Tributary of Little Calfpasture River at FS 382, 8.6 km N Co. Rt. 687, Augusta Co., VA (38° 05’ 34” N, 79° 23’ 44” W)			1.0				1.0				.5	.5	
16	14	Tributary of Little Calfpasture River at FS 382, 12.3 km N Co. Rt. 687, Augusta Co., VA (38° 06’ 13” N, 79° 22’ 25” W)			1.0				1.0				1.0		
17	2	Tributary of Little Calfpasture River at FS 382, 17.3 km N Co. Rt. 687, Augusta Co., VA (38° 06’ 24” N, 79° 20’ 50” W)			1.0				.5	.5			1.0		
18	22	Lynch River at Co. Rt. 628, 1 km E Co. Rt. 614, Greene Co., VA (38° 16’ 01” N, 78° 36’ 25” W)			1.0				.5	.5			1.0		
19	22	Lynch River W of Co. Rt. 614 and E of Co. Rt. 628, Greene Co., VA (38° 15’ 42” N, 78° 35’ 41” W)		.13	.85	.02		.02	.98			.02	.93	.05	
20	12	Roach River E of Co. Rt. 810, Greene Co., VA (38° 15’ 18” N, 78° 32’ 20” W)		.13	.83	.04			.83	.17		.06	.94		
21	20	Haneytown Creek, N of Co. Rt. 631, 0.8 km W Co. Rt. 630, Greene Co., VA (38° 17’ 11” N, 78° 31’ 40” W)		.11	.84	.05							.83	.17	
22	29	Swift Run along US Rt. 33, 0.6 km N Co. Rt. 625, Greene Co., VA (38° 20’ 29” N, 78° 30’ 33” W)			.98	.02			1.0				1.0		
23	2	Hughes River at Co. Rt. 231, Madison Co., VA (38° 32’ 28” N, 78° 14’ 38” W)			1.0				.5	.5			1.0		
24	5	Hazel River at Co. Rt. 600, 3.4 km S Co. Rt. 608, Rappahannock Co., VA (38° 36’ 21” N, 78° 15’ 23” W)			1.0				1.0				1.0		
25	1	Thornton River at Co. Rt. 522, Sperryville, Rappahannock Co., VA (38° 39’ 28” N, 78° 13’ 35” W)			1.0				1.0				1.0		
26	10	Tributary of Passage Creek at Co. Rt. 678, 0.2 km S Co. Rt. 675, Shenandoah Co., VA (38° 46’ 09” N, 78° 29’ 56” W)			1.0			.08	.84	.08			1.0		
27	16	Manassas Run at S shore of Shenandoah River at Co. Rt. 624, Warren Co., VA (38° 57’ 24” N, 78° 07’ 24” W)	.03	.28	.69		.09	.16	.75				.81	.16	.03
28	10	Dry Run at Co. Rt. 638, 0.2 km E Co. Rt. 603, Warren Co., VA (38° 58’ 41” N, 78° 04’ 26” W)			1.0				1.0				1.0		
29	1	Dutchman Creek at Co. Rt. 674, Loudoun Co., VA (39° 17’ 17” N, 77° 39’ 13” W)			1.0				1.0				1.0		
30	1	Milltown Creek just off Co. Rt. 691, 0.2 km W Co. Rt. 287, Loudoun Co., VA (39° 14’ 44” N, 77° 39’ 22” W)			1.0				1.0				1.0		
31	2	Tributary of Potomac River at Co. Rt. 602, 2.1 km N Co. Rt. 603, Fairfax Co., VA (39° 02’ 57” N, 77° 19’ 52” W)			1.0				1.0						
32	1	Tributary of Quantico Creek, Prince William Forest Park, Prince William Co., VA (38° 35’ 20.9” N, 77° 23’ 58.4” W)			1.0				1.0				1.0		
33	2	Mary Bird Branch, Prince William Forest Park, Prince William Co., VA (38° 34’ 04” N, 77° 21’ 39” W)			1.0				.5	.5			1.0		
34	30	Lynch River E of Co. Rt. 810, 0.4 km N Co. Rt. 633, Albemarle Co., VA (38° 14’ 11” N, 78° 32’ 33” W)		.26	.72	.02		.28	.70	.02		.26	.74		
35	13	Roach River at Co. Rt. 603 and 604, Greene Co., VA (38° 15’ 02” N, 78° 30’ 32” W)		.54	.33	.13		.69	.31			.83	.17		
36	1	A seep into Ginkoteague Creek at Port Conway, King George Co., VA (38° 11’ 18” N, 77° 08’ 58” W)		1.0				1.0							
37	3	Chippokes Plantation State Park, Surry Co., VA (37° 07’ 57” N, 76° 43’ 12” W)		1.0				1.0							
38	3	Parker Branch of Roach River at Co. Rt. 633, Greene Co., VA (38° 15’ 41” N, 78° 30’ 16” W)		.5	.5			1.0				.67	.33		
39	2	Welsh Run N of Co. Rt. 617, Greene Co., VA (38° 13’ 35” N, 78° 25’ 40” W)		1.0				1.0				1.0			
40	1	Roach River at Co. Rt. 648, Greene Co., VA (38° 14’ 05” N, 78° 29’ 36” W)		1.0				.5	.5			1.0			
41	21	Lynch River E of Co. Rt. 603, Albemarle Co., VA (38° 13’ 29” N, 78° 31’ 15” W)		.81	.09			.93	.07		.12	.71	.17		
42	1	Buck Mountain Creek at Co. Rt. 601, 0.5 km N Co. Rt. 671, Albemarle Co., VA (38° 12’ 46” N, 78° 34’ 49” W)		1.0				1.0				.5	.5		

Appendix 1 (continued).

Pop.	N	Locality	6-PGDH				GOT-1				PEP				
			a	b	c	d	a	b	c	d	a	b	c	d	e
43	7	Muddy Run on Co. Rt. 687, 1 km E Co. Rt. 810, Albemarle Co., VA (38° 13' 31" N, 78° 36' 59" W)		.86	.14			1.0			.14	.79	.07		
44	4	Doyles River at intersection of Co. Rts. 629 and 810, Albemarle Co., VA (38° 12' 11" N, 78° 40' 18" W)		1.0				1.0			.25	.75			
45	14	North Fork of Rocky Creek at Co. Rt. 671, 0.8 km E Co. Rt. 609, Albemarle Co., VA (38° 09' 33" N, 78° 35' 48" W)		1.0				1.0				.86	.11	.03	
46	3	Doyles River at intersection of Co. Rts. 674 and 810, Albemarle Co., VA (38° 08' 18" N, 78° 39' 51" W)		1.0				1.0			.17	.83			
47	5	Madison Run at Co. Rt. 663, Augusta Co., VA (38° 08' 43.9" N, 78° 49' 21.3" W)		1.0				1.0				1.0			
48	15	Stony Creek 0.8 km from end of Co. Rt. 751, Nelson Co., VA (37° 55' 22" N, 78° 54' 58" W)		1.0				1.0				.93	.07		
49	4	Tributary of Buffalo Creek at Co. Rt. 722, 0.8 km S VA Rt. 56, Nelson Co., VA (37° 42' 04" N, 78° 47' 16" W)		1.0				1.0				1.0			
50	7	Austin Creek at US Rt. 60, Buckingham Co., VA (37° 31' 52" N, 78° 41' 12" W)		1.0				1.0			.21			.43	.36
51	3	Right Hand Fork of Cub Creek at Co. Rt. 644, Appomattox Co., VA (37° 16' 30" N, 78° 48' 34" W)	.33	.67				1.0				.83		.17	
52	5	Bowler Creek at Co. Rt. 628, Appomattox Co., VA (37° 17' 27" N, 78° 41' 39" W)		1.0				1.0				.33		.67	
53	7	Suanee Creek at Co. Rt. 621, Appomattox Co., VA (37° 18' 23" N, 78° 43' 15" W)	.14	.86				1.0				.14		.79	.07
54	15	North Fork of David Creek at Co. Rt. 654, 1.9 km N US Rt. 24, Appomattox Co., VA (37° 26' 15" N, 78° 45' 18" W)		1.0				1.0				.2	.03	.43	.33
55	3	Tributary of Vaughns Creek, 1.5 km S US Rt. 460, Prince Edward Co., VA (37° 15' 44" N, 78° 40' 20" W)	.33	.67				1.0				.66	.17		.17
56	6	Brown's Branch of Buffalo Creek at Co. Rt. 664, 1.4 km S Co. Rt. 669, Prince Edward Co., VA (37° 10' 04" N, 78° 35' 43" W)	.08	.92				1.0				.25		.42	.33
57	3	Tributary of Buffalo Creek at Co. Rt. 686, 0.5 km E Co. Rt. 666, Prince Edward Co., VA (37° 12' 10" N, 78° 31' 53" W)		1.0				1.0						1.0	
58	3	South Fork of Spring Creek at Co. Rt. 757, 0.6 km S Co. Rt. 663, Prince Edward Co., VA (37° 13' 13" N, 78° 40' 21" W)		1.0				1.0						.17	.83
59	3	Opossum Creek at Co. Rt. 677, Campbell Co., VA (37° 20' 06" N, 79° 08' 57" W)		1.0				1.0				.5			.5
60	1	150 m E Co. Rt. 629, 2.25 km N Douthat State Park, Alleghany Co., VA (37° 55' 52" N, 79° 46' 48" W)		1.0				1.0						1.0	
61	6	Bratton Run at intersection of Co. Rts. 780 and 850, Rockbridge Co., VA (37° 53' 13" N, 79° 36' 06" W)		1.0				1.0						1.0	
62	3	Goshen Branch of Calfpasture River at VA Rt. 42, 8.25 km N Co. Rt. 780, 2.5 km S Co. Rt. 687, Rockbridge Co., VA (38° 02' 02" N, 79° 26' 33" W)		1.0				1.0							
63	16	Stuart Run at Co. Rt. 629, 0.2 km N Co. Rt. 633, Bath Co., VA (38° 04' 49" N, 79° 34' 38" W)		1.0				1.0						.67	.33
64	8	White Sulphur Spring Branch of Cowpasture River at Co. Rt. 672, 4.3 km S FS 394, Bath Co., VA (38° 06' 14" N, 79° 34' 31" W)		1.0				1.0						.67	.33
65	2	Unnamed tributary of Cowpasture River at FS 394, 0.2 km E Co. Rt. 627, Bath Co., VA (38° 08' 59" N, 79° 35' 15" W)		1.0				1.0						1.0	
66	4	Tributary of Greenbrier River, Brooks Memorial Arboretum, 3.4 km W Seebert entrance to Watoga State Park, Pocahontas Co., WV (38° 07' 11" N, 80° 09' 25" W)		1.0				1.0						.5	.5
67	5	Tributary of Greenbrier River, 4.2 km E intersection of US Rt. 219 and Anthony Rd, near Anthony, Greenbrier Co., WV (37° 54' 22" N, 80° 20' 32" W)		1.0				1.0						.7	.3
68	3	Tributary of Greenbrier River at Old Roads Trail, 1.4 km S Caldwell entrance to Greenbrier State Forest, Greenbrier Co., WV (37° 44' 34" N, 80° 21' 29" W)		1.0				1.0						1.0	
69	5	Potts Creek, 5.1 km E Co. Rt. 613 on WV Rt. 17, Monroe Co., WV (37° 27' 31" N, 80° 27' 58" W)		1.0				1.0						1.0	

Appendix 1 (continued).

Pop	N	Locality	6-PGDH				GOT-1				PEP				
			a	b	c	d	a	b	c	d	a	b	c	d	e
70	5	7.2 km S intersection of Co. Rt. 29 and 15, between Zenith and Waiteville, Monroe Co., WV (37° 29' 41" N, 80° 26' 24" W)		1.0				1.0						.5	.5
71	4	Trump Lilley Farm, 2.5 km NNW Hinton, Raleigh Co., WV (37° 41' 55" N, 80° 54' 04" W)		.87		.13	.13	.87			.25			.75	
72	1	0.8 km SW intersection of US Rt. 60 and Tommy Hall Rd, S of Rupert, Greenbrier Co., WV (37° 57' 02" N, 80° 41' 23" W)		1.0			.5	.5						1.0	
73	1	Rush Run at New River, near Thurmond, Fayette Co., WV (37° 58' 03" N, 81° 04' 35" W)		1.0				1.0			.5			.5	
74	2	Tributary of Kanawha River, Witcher Creek Rd., Belle, Kanawha Co., WV (38° 13' 46" N, 81° 30' 53" W)		1.0			.25	.75						.5	.5
75	5	Tributary of Beech Fork, 0.9 km SE intersection of Long Branch and Bowen Branch Rds., near Bowen, Wayne Co., WV (38° 18' 02" N, 82° 20' 21" W)	.1	.9			.5	.5						.2	.8
76	6	Tributary of Hisey Fork, 1.2 km SE intersection of US Rt. 52 and Miller Rd., Huntington Co., WV (38° 23' 33" N, 82° 26' 15" W)		1.0			.5	.5						.58	.42
77	1	Tributary of Elk River, 11.9 km SW intersection of WV Rts. 4 and 16 at Ivydale, Clay Co., WV (38° 29' 37" N, 81° 04' 23" W)		1.0			.5	.5						1.0	
78	2	Tributary of Elk River, 4.7 km SW intersection of WV Rt. 4 and Elk River at Gassaway, Braxton Co., WV (38° 39' 33" N, 80° 48' 51" W)		1.0			.5	.5						1.0	
79	2	Rail Trail State Park at intersection of Long Run Rd. and US Rt. 50, 6.5 km W Salem, Doddridge Co., WV (39° 16' 48" N, 80° 40' 39" W)		1.0			.25	.75.						.5	.5
80	2	Tributary of North Hughes River, Jughandle Campground, North Bend State Park, Ritchie Co., WV (39° 13' 23" N, 81° 06' 38" W)		1.0			.5	.5						1.0	

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Prey of American Bullfrogs (*Rana catesbeiana*) from Henry and Patrick Counties, Virginia (Anura: Ranidae)

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ABSTRACT

We identified the stomach contents of 65 American Bullfrogs collected in two counties in Virginia. Both vertebrate and invertebrate prey were consumed, including a worm, mollusks, crustaceans, millipedes, centipedes, spiders, insects, a fish, amphibians, and a mammal. In an analysis of 40 of the stomachs containing food, 91 prey items were identified, a third of which were beetles. Crayfish and millipedes were other major prey, representing 27% and 15% of the total prey items, respectively. Several highly poisonous animals, including the cyanide-producing millipede, *Apheloria tigana,* and the tetrodotoxin-producing salamander, *Notophthalmus viridescens*, were found as prey.

Keywords: beetles, crayfish, diet, *Lithobates catesbeianus,* millipedes, prey.

INTRODUCTION

The American Bullfrog (*Rana catesbeiana* Shaw = *Lithobates catesbeianus* [Shaw]) is widely distributed throughout North America east of the Rocky Mountains but has been introduced as an invasive species to western North America and Hawaii (Casper & Hendricks, 2005). In Virginia, it occurs statewide, being documented in almost every county (Mitchell & Reay, 1999). By the nature of its sheer size (record snout-vent length = 22 cm; Powell et al., 2016), the American Bullfrog is considered a game species in some states. In Virginia, 15 bullfrogs can be harvested per person per day. Adult bullfrogs are ambush predators with a generalist diet consisting of any animal that can fit into their mouth. The full range of prey may never be fully known, but naturalists have and should continue to document prey for this species. A review of the published literature on the bullfrog diet reveals that a variety of techniques have been used to collect such information, ranging from non-lethal techniques, such as stomach flushing and direct observation, to lethal techniques including gigging, hand grabbing, use of an "electro-frogger" (a device that stuns frogs which can then be dip-netted), shooting animals with a .22 caliber rifle, and dissection of preserved museum specimens (Korschgen & Moyle, 1955; Rice & Taylor, 1993; Jancowski & Orchard, 2013). Needham (1905) used a hook and line baited with a little piece of red silk that he "flirted near the bullfrog's head" and reported successful capture of every frog using this technique, but only if the frog was properly approached.

Numerous studies of bullfrog diet have been summarized by Bury & Whelan (1984), Casper & Hendricks (2005), and Dodd (2013), but little has been published concerning bullfrog diets in Virginia. Brooks (1959, 1964) studied the diet of five ranid frogs, including bullfrogs. He concluded that insects and spiders were the most abundant prey found in the stomachs of 138 bullfrogs he captured at five ponds in southeastern Hanover County. Most published studies identify arthropods and other prey only to the family level, as Brooks (1964) did; very few studies identify prey items to the genus or species level. Multidisciplinary teams of herpetologists working with entomologists and other taxonomic experts are needed to accurately identify all prey items to the species level.

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[1] Deceased

MATERIALS AND METHODS

In late July 2009, 25 frozen bullfrog stomachs were given to the first author (JG) by a citizen of Henrico County, Virginia, who was an avid hunter of bullfrogs. The hunter had attended a master naturalist training event taught by JG and learned of JG's interest in frogs. JG dissected the 25 stomachs to quickly assess the type of prey these frogs had eaten. The contents from these stomachs were preserved in a container of alcohol. From late July to mid-August, the hunter harvested an additional 64 bullfrogs. This time he froze the entire bullfrog carcasses except for the hind legs. All of the frogs were collected between 24 July and 18 August 2009 from private farm ponds and the margin of Philpott Lake in Patrick and Henry counties, Virginia. This second batch of 64 bullfrog carcasses were more methodically dissected by JG's high school biology students, who placed all prey into plastic bags containing alcohol.

Of the 64 bullfrog carcasses, 24 had empty stomachs (37.5%). The bags with prey items from the remaining 40 bullfrogs and the preserved contents from the other 25 bullfrog stomachs were later examined by the second author, who attempted to identify each prey item to the lowest possible taxonomic level. Many of the prey were too digested to identify.

RESULTS

Table 1 summarizes the prey found in the 65 bullfrog stomachs which contained food items. Table 2 shows the total number of animals collected from the 40 more carefully dissected bullfrog stomachs. Of 91 prey items, 33% were beetles, 27% were crayfish, and 15% were millipedes. The largest prey item by mass was a 7.4 cm mouse (*Peromyscus* sp.) and the longest prey was a 11.9 cm Three-lined Salamander (*Eurycea guttolineata*). In addition to animal prey, there was a variety of inanimate objects in some bullfrog stomachs, including rocks, *Pinus virginiana* needles, unidentified tree leaves, a male pine cone, grass, sticks, and a flower bud. Presumably these objects were inadvertently ingested when live prey were being subdued and swallowed. Several stomachs contained bird feathers, but no bird carcasses, perhaps suggesting failed capture attempts.

DISCUSSION

An analysis of the prey items suggests that the American Bullfrog has behavioral or physiological adaptations which allow it to tolerate venomous and poisonous animals. For example, one bullfrog stomach contained a red eft (*Notophthalmus viridescens*) and two *Apheloria tigana* millipedes. Efts are known to produce skin secretions composed of tetrodotoxin, a very potent voltage-gated sodium channel blocker which causes flaccid paralysis (Brodie, 1968). *Apheloria* millipedes are cyanogenic, meaning they are capable of producing hydrogen cyanide (HCN) and benzoyl cyanide (Shear, 2015). These chemicals disrupt cellular metabolism by stopping the electron transport chain, thus causing the failure of ATP production. Marek & Bond (2009) report that one *Apheloria* millipede "can secrete 18-fold the amount of hydrogen cyanide necessary to kill pigeon-sized birds." Eisner et. al (1967) estimated that a 1 g millipede secreted 0.4 times the lethal dose to kill a 25 g frog. Benzaldehyde, another chemical defense molecule secreted by *Apheloria*, is a mucus membrane irritant. Other millipedes consumed by the bullfrogs in our study produce many other irritating chemicals. *Oxidus gracilis*, in addition to being cyanogenic, produces phenol and benzoic acid (Duffy et al., 1977). Millipedes of the genus *Narceus* produce benzoquinone (Monro et. al., 1962). Other prey that are rarely eaten by vertebrates are carabid beetles of the genus *Brachinus* (Juliano, 1985). Also known as bombardier beetles, they produce a hot, explosive, irritating chemical spray containing quinones (Brandmayr et al., 2009).

Venomous animals capable of biting or stinging, including several species of centipedes (Chilopoda) and hymenopterans, such as ants and bees, were consumed in small numbers by the bullfrogs examined in our study. Prey with sharp and pointy exoskeletons such as the crayfish *Cambarus cf. bartonii* were consumed by numerous frogs and the large (45 mm long, 17 mm wide) longhorn beetle *Prionus laticollis* was found in one frog's stomach. A whole Green Sunfish (*Lepomis cyanellus*) with very sharp spines was also found as prey.

One vertebrate prey item, the Three-lined Salamander (*Eurycea guttolineata*), documented during our study has not been reported in the literature as being prey of the bullfrog (Petranka, 1998; Ryan & Douthitt, 2005). However, it seems likely that this salamander and others would be easily and frequently consumed by the American Bullfrog. In general, our list of prey items suggests that American Bullfrogs collected in the study areas rely primarily on terrestrial organisms and forage away from water. When our prey list is compared with other diet studies for this species, it appears that the

Table 1. Prey items collected from 65 *Rana catesbeiana* stomachs in Henry and Patrick counties, Virginia. Bold headings are classes followed by order, family, genus and species.

INVERTEBRATES		
Clitellata		
Haplotaxida	Lumbricidae	
Mollusca		
Gastropoda		
Crustacea		
Decapoda	Cambaridae	*Cambarus cf. bartonii*
Isopoda	Oniscidea	
Diplopoda		
Polydesmida	Cleidogonidae	*Cleidogona major*
	Paradoxosomatidae	*Oxidus gracilis*
	Xystodesmidae	*Apheloria tigana*
Spirobolida	Spirobolidae	*Narceus americanus*
Chilopoda		
Scolopendromorpha	Cryptopidae	*Scolopocryptops sexspinosus*
	Scolopendridae	*Hemiscolopendra marginata*
Arachnida		
Araneae	Pisauridae	*Dolomedes sp.*
Insecta		
Blattaria	Blattidae	*Cryptocercus punctulatus*
Coleoptera	Carabidae	*Brachinus* sp.
		Carabus limbatus
	Cerambycidae	*Prionus laticollis*
	Curculionidae	*Naupactus leucoloma*
	Elateridae	*Hemicrepidius memnonius*
	Scarabaeidae	*Macrodactylus subspinosus*
		Osmoderma scabra
Hymenoptera	Apoidea	
	Formicidae	
Lepidoptera		
Odonata		
Orthoptera		
VERTEBRATES		
Actinopterygii		
Perciformes	Centrarchidae	*Lepomis cyanellus*
Amphibia		
Caudata	Plethodontidae	*Eurycea guttolineata*
	Salamandridae	*Notophthalmus viridescens*
Anura		
Aves (feathers only)		
Mammalia		
Rodentia	Muridae	*Peromyscus* sp.

Table 2. Stomach contents of 40 *Rana catesbeiana* from Henry and Patrick counties, Virginia. N = total number of prey.

Taxonomic Group	N	% Total
ANNELIDA	1	1
MOLLUSCA		
Gastropoda	3	3.3
CRUSTACEA		
Decapoda	25	27.4
Isopoda	2	2.2
DIPLOPODA	14	15.4
CHILOPODA	1	1
INSECTA		
Coleoptera	30	33
Hymenoptera	1	1
Lepidoptera	1	1
Orthoptera	1	1
Odonata	1	1
Unidentified larva	1	1
VERTEBRATA		
Anura (tadpole)	1	1
Anura (adult)	1	1
Caudata	3	3.3
Aves (feathers)	4	4.4
Mammalia	1	1
TOTAL	91	100

dominant prey consumed is a product of prey availability for that habitat, not an innate preference for specific food. Much remains to be learned about the diet of the bullfrog in Virginia, thus we encourage others to publish their observations of dietary items for this species.

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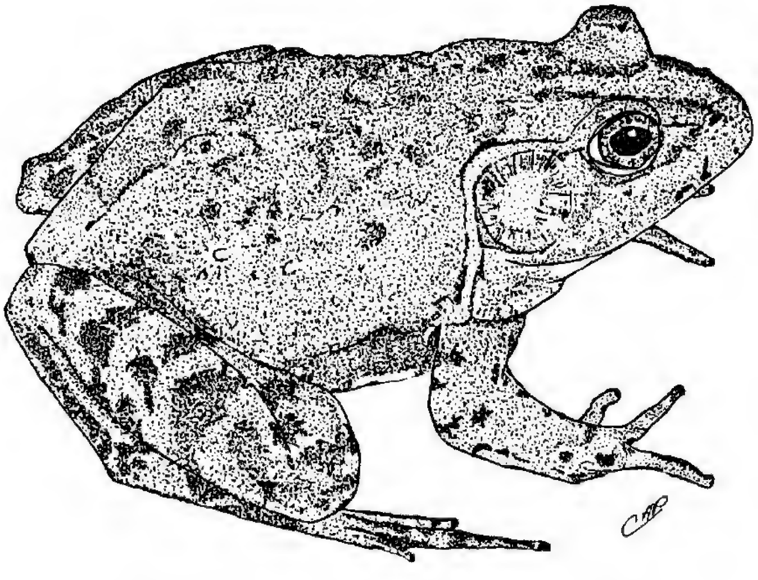

American Bullfrog (*Rana catesbeiana* Shaw, 1802)

Original drawing by Christopher A. Pague

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New Virginia Records of Trichoptera and Neuroptera (Insecta)

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ABSTRACT

Three caddisflies (Trichoptera) and one antlion (Neuroptera) are reported from Virginia for the first time, including the second known specimen of *Ochrotrichia weoka* Harris (Hydroptilidae), a species previously known only from the holotype described 30 years ago from Alabama. Additional Virginia records are provided for two other species recently reported from the state.

Keywords: antlion, caddisfly, distribution, new state records.

The caddisfly (Trichoptera) fauna of Virginia was recently summarized in a series of papers by Flint et al. (2004, 2008, 2009), with additional records provided by Flint (2011, 2014, 2017). The most recent tally accounts for 371 species recorded from the state, which currently ranks as the highest documented total for any US state (the figure of 383 for Tennessee includes dozens of species known from neighboring counties of adjacent states; Etnier et al., 1998). Several additional taxa are known in Virginia only from female specimens; the eventual capture of males may confirm those suspected state records. We are also aware of recent collections of several apparently undescribed species in the genera *Hydroptila*, *Ochrotrichia*, and *Pycnopsyche* in the state (e.g., see Flint, 2017).

The Neuropterida fauna of Virginia was reviewed by Flint (2015), who documented 89 species (71 Neuroptera, 18 Megaloptera), including 11 antlions (Myrmeleontidae).

In this paper, we report three caddisflies and one antlion from Virginia for the first time, and provide additional records for two other species recently reported from the state. Except as noted, all specimens listed below are deposited in the collection of the National Museum of Natural History (NMNH), Smithsonian Institution, Washington, D.C., and were identified by the second author.

---

[1] Deceased

Trichoptera

Family Limnephilidae

Pycnopsyche sonso (Milne, 1935)

Flint et al. (2008) removed *P. sonso* from the Virginia Trichoptera list after determining that the specimens studied by Parker & Voshell (1981) and all others seen by Flint were assignable to a newly described species, *Pycnopsyche pani* Wojtowicz & Flint, 2007. However, Morse et al. (2017) retained Virginia in the range statement for *P. sonso* on the basis of the older records (see Rasmussen & Morse, 2018). Wojtowicz & Flint (2007) concluded that *P. sonso* is a southern Appalachian species, its range extending from North Carolina to Georgia, whereas *P. pani* has a more northern distribution, being known primarily from the mountains of Virginia, with two collections from high elevation sites in North Carolina.

We believe the following collection represents the first confirmed record of *P. sonso* from Virginia, constituting a range extension of more than 100 km from Sevier Co., Tennessee (Wojtowicz, 1982; Etnier et al., 1998).

Scott Co., Natural Tunnel State Park, Cove Ridge Center, N36.710 W82.743, mercury vapor light, 2 October 2017, S.M. Roble, E.C. Orcutt, Z. Bradford, R. Hypes (1♂). **NEW STATE RECORD.**

Family Polycentropodidae

Plectrocnemia remota (Banks, 1911)

Described by Banks (1911) as *Polycentropus remotus*, this widespread, transcontinental North American species was transferred to the genus *Plectrocnemia* a century later by Chamorro & Holzenthal (2011). Its range extends from Alaska and Newfoundland south to Illinois, Kentucky, Pennsylvania, and Delaware (Morse et al., 2017). It has not been recorded from Maryland or West Virginia (Tarter & Floyd, 2016; Morse et al., 2017). The Virginia locality is at or near its southern range limit.

Augusta Co., George Washington National Forest, FS42 at Maple Flats area nr. North Pond, N37.975 W78.997, uv, 10 June 2017, S.M. Roble (2♀♀). **NEW STATE RECORD.**

Family Sericostomatidae

Agarodes crassicornis (Walker, 1852)

Flint et al. (2009) listed two collections containing two specimens each of this predominantly southern species from Fort A.P. Hill Military Reservation in Caroline Co., the first documentation for Virginia. Malaise trap sampling by E. C. Orcutt at a nearby boggy wetland on the base during the period of 11 May–6 July 2017 has revealed that *A. crassicornis* is common to abundant in this habitat, with more than 50 adults having been captured.

Family Hydroptilidae

Ochrotrichia weoka Harris, 1989

Harris (1989) described this species on the basis of a single male from Elmore Co., Alabama, west of the city of Auburn. Prior to its recent discovery in Virginia, it was still known only from this unique specimen nearly three decades later. Surprisingly, the second specimen of *O. weoka* has been taken in northern Virginia, representing a range extension of approximately 1,000 km.

Fauquier Co., Arlington Outdoor Lab[oratory], N38.807 W77.723, Malaise trap, 24 May–15 June 2017, D.[R.] Smith & O.[S.] Flint (1♂; det. S.C. Harris). **NEW STATE RECORD.**

These three additions increase the number of caddisflies documented in Virginia to 374 species.

Neuroptera

Family Myrmeleontidae

Flint (2015) recorded two species of *Myrmeleon* from Virginia and noted that this large genus of antlions was being revised. The following collection adds another member of the genus to the known Virginia fauna.

Myrmeleon mobilis Hagen, 1888

City of Suffolk, South Quay Pine Barrens Natural Area Preserve, Malaise trap in longleaf pine stand, N36.5583 W76.9081, 19 July–1 August 2017, E. Orcutt (1). **NEW STATE RECORD.**

Sussex Co., Chub Sandhill Natural Area Preserve, Malaise trap in pine stand, 1–25 August 2017, N36.8711 W77.1822, M. Ayers and O. Latham (1); same but forest edge, bottomland, Malaise trap, N36.8716 W77.1875, 13 September–18 October 2017, E.C. Orcutt and O. Latham (1).

Penny et al. (1997) listed the documented range of *M. mobilis* as including Alabama, Florida, Georgia, Missouri, and North Carolina. The Virginia records represent a northward range extension.

Family Ithonidae

Polystoechotes punctata (Fabricius, 1793)

This "giant lacewing" and several close relatives were long placed in their own family (Polystoechotidae), but Winterton & Makarkin (2010) synonymized it with Ithonidae. Dowell & Penny (2019) reported that *P. punctata*, a boreal species, has disappeared from the eastern portion of its range (no records east of the Rocky Mountains in the past 60 years). Flint (2015) did not include this species in his review of Virginia Neuropterida, but the range map in Dowell & Penny (2019) suggests that the species was historically documented in the state. However, no specimens of *P. punctata* were seen by the authors (R. Dowell, pers. comm.), so the species should continue to be regarded as being undocumented from Virginia.

Family Chrysopidae

Leucochrysa (*Nodita*) *callota* Banks, 1915

This primarily Gulf Coast species was newly recorded for Virginia by Flint (2015), who cited collections from Isle of Wight, Northampton, and Sussex counties in the southeastern corner of the state. The following recent collection is from this same general area:

City of Suffolk, South Quay Sandhills Natural Area Preserve, Malaise trap in longleaf pine stand, N36.5583 W76.9081, 1–9 August 2017, E.C. Orcutt (2); same but 9–25 August 2017, M. Ayers and O. Latham (2).

Acknowledgments

Ellison Orcutt, Megan Ayers, and Olivia Latham of the Virginia of the Department of Conservation and Recreation, Division of Natural Heritage, collected some of the specimens cited above incidental to their surveys for native bees in Virginia. Arthur V. Evans kindly set up uv lights in the Maple Flats area of the George Washington National Forest during the June 2017 national meeting of the Dragonfly Society of the Americas. For nearly a decade, David R. Smith, U.S. Department of Agriculture retired, has led the Malaise trapping efforts in the Bull Run Mountains that resulted in the capture of *Ochrotrichia weoka.* Boris C. Kondratieff provided comments on the manuscript.

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The Ant-like Leaf Beetles (Coleoptera, Aderidae) of the George Washington Memorial Parkway, Fairfax County, Virginia

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ABSTRACT

Malaise trap samples collected during a 20-year period (1998–2018) from four national park sites in northern Virginia were sorted for ant-like leaf beetles (Coleoptera, Aderidae). Nine species and one undetermined taxon were documented. The most common species in the study area is *Zonantes subfasciatus* (LeConte). The first Virginia records were documented for *Aderus brunnipennis* (LeConte), *Emelinus melsheimeri* (LeConte), and *Vanonus calvescens* Casey, with the latter representing a southern range extension. Periods of adult activity, based on dates of capture, are given for each species. Relative abundance is noted for each species based on the number of captures. Images are provided showing variation in elytral markings of *Zonantes fasciatus* (Melsheimer) and Z. *subfasciatus* from Virginia.

Keywords: Malaise trap, national park, new state records, Potomac River Gorge.

INTRODUCTION

Little is known concerning the bionomics of ant-like leaf beetles (Coleoptera, Aderidae). Their heads have a somewhat ant-like appearance and the largest North American species are only 4 mm long. They are most often collected on the underside of the leaves of woody angiosperms and seem to have a special affinity to oaks (*Quercus* sp.) in North America and Mexico (Chandler, 2002). Larvae have been found in rotting wood, leaf litter, under loose bark, and in the nests of bees and termites (Chandler, 2002). Although the family was revised by Werner (1990), the fauna of western North America contains many undescribed species, especially in the south where Neotropical genera reach their northern limits (Chandler, 2002). There are about 50 described genera containing nearly 1,000 species worldwide, but concentrated in the tropics. In North America, there are 11 genera containing 48 described species (Chandler, 2002). All 11 genera and 37 species are found in eastern North America (Evans, 2014). Aderid beetles are often found in Baltic and Bitterfeld amber deposits dating from 20 to 40 million years ago (Alekseev & Grzymala, 2015).

STUDY SITES

The study area lies within the George Washington Memorial Parkway (GWMP) in Fairfax County, Virginia, and is managed by the National Park Service. Two study sites, Great Falls and Turkey Run parks, are in the Piedmont physiographic province, whereas the other two, Dyke Marsh Wildlife Preserve and Little Hunting Creek, are on the Coastal Plain. A map of these park sites is provided in Steury (2011). All sites are situated near the shore of the Potomac River and contain primarily upland and floodplain deciduous woodlands.

MATERIALS AND METHODS

Six Townes style Malaise traps were set at Dyke Marsh from April 1998–December 1999 in narrow-leaf cattail (*Typha angustifolia* L.) marsh, in floodplain forest dominated by red and silver maple (*Acer rubrum* L. and *A. saccharinum* L.) and tulip poplar (*Liriodendron tulipifera* L.), and at the marsh/forest ecotone. Three Malaise traps were also set at Great Falls and Turkey Run parks from March 2006–November 2009 in upland and floodplain deciduous forest, and in a deciduous swamp forest. Four more traps were set at Little Hunting Creek from March–November 2017–2018, in upland forest dominated by an ericaceous understory and a canopy of oaks (*Quercus* sp.), hickory (*Carya* sp.), American beech (*Fagus grandifolia* Ehrh.), and some Virginia pine (*Pinus virginiana* Mill.). Beetles were removed from the samples by citizen science volunteers and aderid beetles were removed from these subsamples by the author. Collectors included C. Acosta, E. Barrows, C. Davis, A. Evans, D. Smith, and B. Steury. Specimens were pinned, labeled, and deposited in the collections maintained at the GWMP, Turkey Run Park Headquarters in McLean, Virginia. State record determinations were based on reviews of Werner (1990), Downie & Arnett (1996), Ciegler (2014), and Gompel (2017).

RESULTS AND DISCUSSION

Three tribes, containing three subtribes, five genera, nine species, and one undetermined taxon were documented from the study areas. The most commonly collected species at the study sites was *Zonantes subfasciatus* (LeConte). Three species new to Virginia, *Aderus brunnipennis* (LeConte), *Emelinus melsheimeri* (LeConte), and *Vanonus calvescens* Casey, were documented from the study area. The *V. calvescens* record represents a southern range extension from Pennsylvania (Downie & Arnett, 1996). The ten taxa recorded in the study area is more than the total (n=9) found in all of Canada (Majka, 2011) but only about half of the South Carolina fauna (n=19; Ciegler, 2014). Brown (2008) did not include aderid beetles in the checklist of the invertebrate fauna of the Potomac River Gorge, located between Maryland and Virginia, an area with over 100 years of biodiversity studies. Thus, all species captured during this study, each of which was collected in Great Falls or Turkey Run parks, represent the first records for the gorge. An undetermined female *Vanonus* sp. (near *uniformis* Werner) collected in Great Falls Park may be the undescribed female of *V. uniformis*.

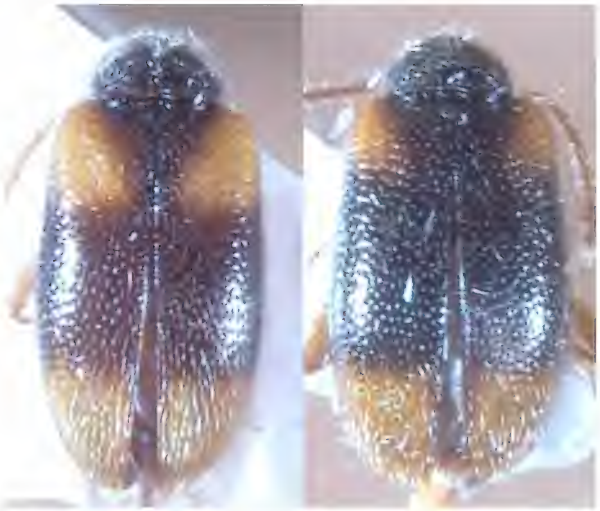

Fig. 1a-b. *Zonantes fasciatus* (Melsheimer) from Dyke Marsh Wildlife Preserve (left) and Little Hunting Creek (right), Fairfax County, Virginia, showing variation in the length of the dark, median elytral band.

LIST OF SPECIES

Taxonomic order of tribes and subtribes follows Chandler (2002). Species are listed alphabetically. The number of specimens in the GWMP collection is indicated in parentheses or listed as "common" if the species was too abundant to save all specimens. Collection sites are abbreviated as follows: Dyke Marsh Wildlife Preserve (DM), Great Falls Park (GF), Little Hunting Creek (LH), and Turkey Run Park (TR). The periods of adult activity are given based on dates when Malaise traps were set and collected. Dates separated by a hyphen indicate that the taxon was documented on at least one day during each month within this continuum of months, whereas dates separated by a comma represent individual observation dates. For traps set over multiple weeks, the first day of the set is used as the earliest date and the last day of the set as the last date.

Aderidae

Tribe Euglenesini

Subtribe Euglenesina

Zonantes fasciatus (Melsheimer) (Fig. 1a-b) – (10); DM, GF, LH; 1 June–21 October.

Zonantes hubbardi Casey – (3); GF, TR; 22 Jun–25 Aug.

Zonantes subfasciatus (LeConte) (Fig. 2a-d) – (common); GF, LH; 1 May–1 December. Capture dates are based on a subset of captured specimens retained for the collection (n = 13).

Tribe Emelinini

Emelinus melsheimeri (LeConte) – (3); GF, LH; 2 June–21 October. **NEW STATE RECORD**. This species has been documented from Florida to northeastern Mexico and eastern Arizona, north to Illinois and Massachusetts. It has been recorded from the District of Columbia, Maryland, Pennsylvania, and West Virginia (Werner, 1990; Downie & Arnett, 1996), so it is not surprising to find it in Virginia.

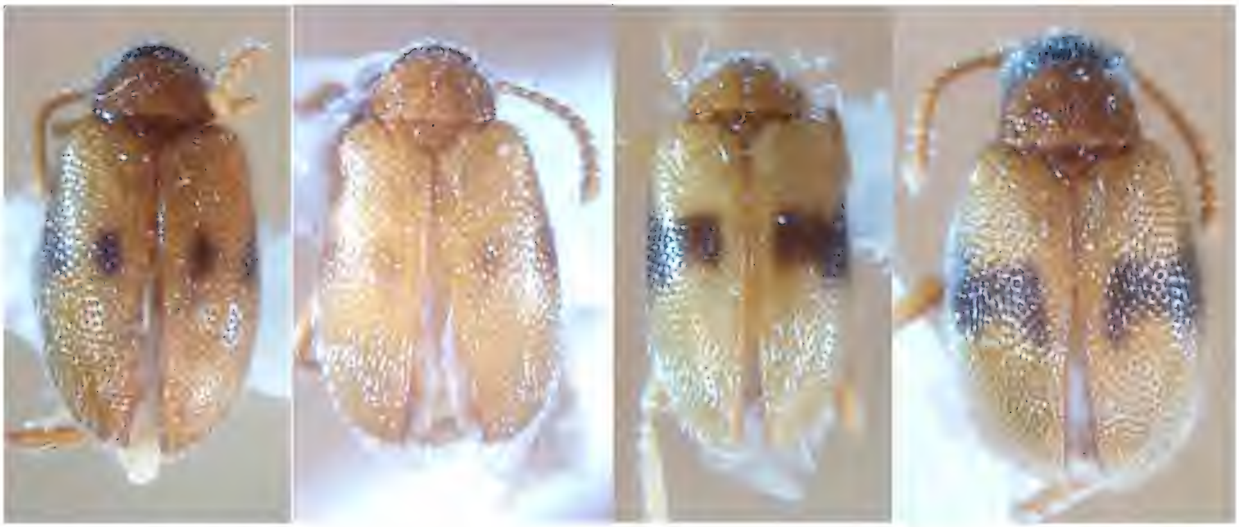

Fig. 2a-d. *Zonantes subfasciatus* (LeConte), all from Great Falls Park, Fairfax County, Virginia, showing variation in markings of the median elytral band.

Tribe Aderini

Subtribe Aderina

Aderus brunnipennis (LeConte) – (5); DM, GF, TR; 1 May–5 June, 19 Sep–21 Oct. **NEW STATE RECORD.** The documented range of *A. brunnipennis* extends from Florida to eastern Texas, north to Pennsylvania and Kansas. It is also recorded from the District of Columbia, Maryland, Pennsylvania, and West Virginia (Werner, 1990; Downie & Arnett, 1996; Gompel, 2017). The GWMP records close a narrow gap in its documented range.

Subtribe Syzetoninina

Vanonus calvescens Casey – (1); GF; 14–26 July. **NEW STATE RECORD.** This record represents a southern range extension from Pennsylvania. The species has been documented from Québec, Canada, along the East Coast south to Pennsylvania and west to Wisconsin (Werner, 1990; Downie & Arnett, 1996).

Vanonus sp. (near *uniformis* Werner) – (1♀); GF; 16–30 July. The elytra pubescence of this specimen is most similar to descriptions of male *V. uniformis*, a species for which the female has not been described (Werner, 1990). However, this specimen differs from descriptions of male *V. uniformis* in being only 1.4 mm long, instead of 1.63 mm, having slightly shorter antennae than reported in males, and possessing the antebasal transverse depression of the pronotum not present in males. *Vanonus uniformis* is documented only from Florida to Arkansas (Werner, 1990).

Vanonus vigilans Casey – (1); GF; 27 July–14 August.

Elonus basalis (LeConte) – (9); GF, LH, TR; 1 June–30 July. This genus was recently reviewed by Gompel (2017).

Elonus nebulosus (LeConte) – (7); LH, TR; 1–20 June, 5-25 August.

ACKNOWLEDGMENTS

Appreciation is extended to our bug lab volunteers and to Don Chandler for determining the specimens of *Vanonus calvescens* and *Vanonus* sp. (near *uniformis*). Steve Roble, Virginia Department of Conservation and Recreation, Division of Natural Heritage, Warren E. Steiner, Jr., Department of Entomology, National Museum of Natural History, Smithsonian Institution, and an anonymous reviewer provided helpful comments on the draft manuscript.

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Shorter Contributions

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Two Beetles New to Virginia (Coleoptera: Cantharidae, Erotylidae)

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ABSTRACT

Malaise traps set along Little Hunting Creek in 2017 and 2018 on lands managed by the National Park Service as part of the George Washington Memorial Parkway captured two beetle species (*Cryptophilus obliteratus* and *Tytthonyx erythrocephala*) previously undocumented from Virginia. Specimens are deposited in the collection maintained at the Turkey Run Park Headquarters in McLean, Virginia. These two captures are discussed below.

Keywords: Fairfax County, Little Hunting Creek, Malaise trap, national park, new state record.

VIRGINIA

Tytthonyx erythrocephala (Fabricius) – Fairfax Co.: Little Hunting Creek, Malaise trap, 20–30 June 2017, B. Steury, C. Davis & C. Acosta (George Washington Memorial Parkway [GWMP], 2); same location, 14–28 June 2018, B. Steury & C. Davis (GWMP, 3). **NEW STATE RECORD.**

There are few published records for this soldier beetle (Cantharidae). Downie & Arnett (1996) report records from Illinois, Indiana, and Ohio. Ulke (1902) adds a record from the District of Columbia. The Maryland Biodiversity Project (2018) which contains 2,226 coleopteran records does not include any documentation for this beetle from Maryland. Pelletier & Hébert (2014) did not include *Tytthonyx* in their survey of northeastern North American cantharids. However, its range is apparently broader than published records indicate. BugGuide (2018) includes images attributed to this distinctive beetle from Georgia, Kansas, Louisiana, Massachusetts, Mississippi, Missouri, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, Tennessee, and Texas. Ramsdale (2002) states that nothing is known about the ecology of *Tytthonyx*. These four specimens were captured in mature forest dominated by broadleaved hardwoods, especially oaks (*Quercus* sp.), hickory (*Carya* sp.), and American beech (*Fagus grandifolia* Ehrh.), and some Virginia pine (*Pinus virginiana* Mill.). The understory is strongly ericaceous and dominated by blueberry and deerberry (*Vaccinium* sp.) and huckleberry (*Gaylussacia* sp.). A narrow band of shrubby marsh is found along the bank of Little Hunting Creek approximately 20 m from the Malaise trap. The cantharid beetle *Malthinus occipitalis* LeConte was also captured at this site. The capture of *T. erythrocephala* increases the number of cantharid beetles documented from GWMP to 39 species (Steury, 2018b; Steury et al., 2018).

Cryptophilus obliteratus Reitter (Fig. 1) – Fairfax Co.: Little Hunting Creek, Malaise trap, 1 March–11 April 2018, B. Steury & C. Davis (GWMP, 1). **NEW STATE RECORD.**

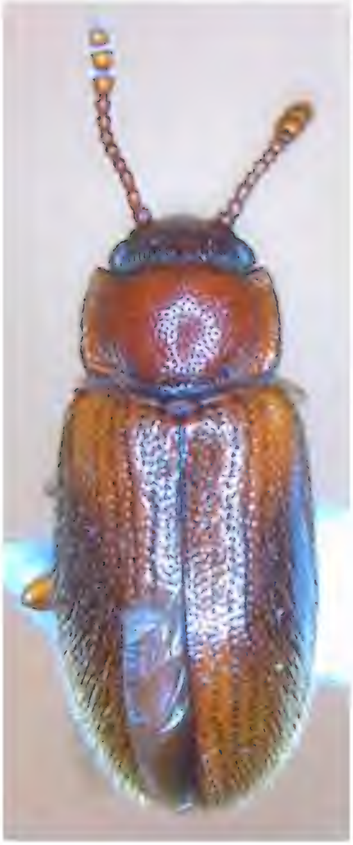

Fig. 1. *Cryptophilus obliteratus* Reitter, Little Hunting Creek, Fairfax County, Virginia, Malaise trap, 1 March – 11 April 2018. Length 2.5 mm. Collectors, Brent Steury & Colin Davis.

This pleasing fungus beetle (Erotylidae) was introduced from the Palearctic Region (Esser, 2017) sometime before 1924 (Casey, 1924). *Cryptophilus seriatus* Casey, described from the Nearctic Region, is a junior synonym of *C. obliteratus* (Esser, 2017). In North America, this species has been reported on the East Coast from Maine to Pennsylvania and Maryland, west to Iowa (Lawrence & Vaurie, 1983; Esser, 2017). The Little Hunting Creek specimen was captured in deciduous woodland dominated by American beech and oaks, with deep leaf litter and large rotting logs. This record increases the number of erotylid beetles known from the GWMP to 21 species and one subspecies (Steury, 2018a).

ACKNOWLEDGEMENTS

Appreciation is extended to bug lab volunteers Ann Kelly and Jerry Taylor for finding these beetles in the Malaise trap samples. Steve Roble, Virginia Department of Conservation and Recreation, Division of Natural Heritage, and two anonymous reviewers provided helpful comments on the draft manuscript.

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Obituary

Joseph C. Mitchell
(1948–2019)

Dr. Joseph ("Joe") Calvin Mitchell, age 70, was tragically killed in a pedestrian-motor vehicle accident on the morning of July 2, 2019, near his residence outside of Gainesville, Florida. He was widely regarded as the leading expert on the herpetofauna of his native state of Virginia and can also be considered the founding father of the Virginia Natural History Society. A longtime resident of Richmond, Joe was born on August 16, 1948, in Lynchburg, Virginia, but his family moved from Bedford to Richmond when he was still young. His father was a blue collar worker in the maintenance section of a local bank chain and his mother was a stay at home mom. Joe was the oldest of four children (two brothers and one sister), a proud father of four (two daughters and two sons), grandfather of two, and had been married three times (Virginia "Ginny" [1973–1978] and Wendy [1979–2003] were fellow biology students at Virginia Commonwealth University). Joe and his widow, Dr. Susan Walls, a US Geological Survey amphibian biologist based in Gainesville, were married in February 2006. Ironically, Joe published a brief autobiography and his complete bibliography (through mid-2018) earlier this year through the Division of Amphibians and Reptiles at the Smithsonian Institution's National Museum of Natural History (Mitchell, 2019a).

Joe became interested in snakes at an early age and often credited his uncle Costello ("Cos") Craig, an amateur herpetologist, for fostering his interest in herpetology and natural history (Mitchell, 1998). Cos and his sons Mark, Brian, and Jerry maintained a collection of captive snakes, which they used to conduct educational programs for the Boy Scouts and other groups in the Bedford area. Joe's parents tolerated his desire to keep captive snakes, a practice he continued for the rest of his life, including having copperheads up until his death. When he was a senior at Hermitage High School, the *Richmond Times Dispatch* newspaper published a feature article about Joe's woodworking skills (he had won several local awards) and his interest in herpetology. Late in his life, Joe rekindled his interest in woodworking.

Joe graduated from high school in 1966 and spent that summer as an apprentice to a master furniture maker. Joe thought that he was destined to become a master craftsman but instead enlisted in the US Marine Corps on his 18th birthday, which was during the Vietnam War era. Uncle Cos was a Marine and his positive experience with that branch of the military contributed to Joe's decision. Joe served in the Marines from 1966–1970, during which time he was stationed at military bases in six states, some of which he returned to decades later to conduct herpetological surveys and research as a consulting biologist.

Upon completion of his military service, Joe returned to Richmond and enrolled at Virginia Commonwealth University (VCU), where he earned a BS in Biology in 1974. For his senior research project, Joe studied corn snake morphometrics, which resulted in his first substantial paper, published in *Copeia* three years later. Joe then pursued graduate studies at Arizona State University under John ("Jack") Fouquette, Jr., where he earned a M.S. in Biology in 1976. For his Master's thesis research, Joe conducted a 1-year study of niche overlap and reproduction in four species of whiptail lizards in the deserts of southeastern Arizona. Subsequently, Joe enrolled in the Ph.D. ecology program (one of the first of its kind in the nation) at the University of Tennessee. He earned his Ph.D. in 1982 under Arthur ("Sandy") Echternacht, who had also been a Fouquette student. For his dissertation research, Joe trapped turtles nearly every day for three years at a series of former golf course ponds near Richmond, resulting in >6,000 captures of about 1,950 individual turtles. He published five papers based on this study, including one on the population ecology and life histories of the two most common species, Painted Turtle (*Chrysemys picta*) and Musk Turtle (*Sternotherus odoratus*), and four other papers on their reproductive cycles.

Joe was deeply passionate about herpetology but he never had a regular, full-time academic or government job. He was proud of the fact that he was able to be a successful, self-employed herpetologist and conservation biologist throughout his career, and liked

Teenage Joe Mitchell with captive Timber Rattlesnake (*Crotalus horridus*) at residence of his uncle Costello Craig in Bedford County, Virginia, ca. 1966. Joe often credited "Cos" with fostering his love of reptiles and ultimately his desire to become a professional herpetologist (photo courtesy of Mitchell family).

Joe Mitchell was proud to have served in the Marines from 1966–1970, calling his decision to enlist on his 18th birthday "the best decision of my life" (photo courtesy of Mitchell family).

Joe Mitchell taking a break from herpetological field surveys, San Luis Potosí, Mexico, June 1971 (Rick Sanderson photo).

Attendees of the Virginia Herpetological Society meeting at the University of Richmond, October 9, 1982; front row, left to right: Joe and Wendy Mitchell (with son Joshua), Richard Hoffman, Frank Tobey (primary VHS co-founder), and Costello Craig (Joe's uncle) (photo courtesy of Joseph C. Mitchell).

being his own boss. Over the years, he had temporary teaching positions at VCU, the University of Richmond (UR), J. Sargeant Reynolds Community College, Randolph-Macon College, and the College of William and Mary. His longest affiliation was with UR, where Joe taught in the 1980s and 1990s and the biology department provided him with research space and grant administrative support for several decades (ending in 2006). Joe taught a night course on Conservation Biology in the UR School of Continuing Studies that was one of the first of its kind in the country. He received a Distinguished Faculty Award from UR for the 1993–1994 academic year.

George Zug, (now retired) curator of amphibians and reptiles at the National Museum of Natural History (NMNH), Smithsonian Institution, was an important mentor to Joe. George introduced Joe to scientific research and museum collections when the latter was still an undergraduate at VCU. Later, George appointed Joe as a NMNH research associate, an affiliation that was maintained from 1983–2007 (final year corresponded with George's retirement). Joe and George traveled separately to Nepal and later coauthored several papers on that country's herpetofauna. Joe also made trips to Mexico, Costa Rica, Nicaragua, and Peru to observe or collect amphibians and reptiles.

Joe was a member of the Virginia Herpetological Society (VHS) for more than 50 years. As a young teenager, he attended his first VHS meeting in 1963 with his uncle "Cos." There he met Frank Tobey (1919–2010), the society's founder, with whom Joe maintained ties for nearly 50 years until Tobey's death (Mitchell, 2011). The VHS focused solely on Virginia herpetology and had the goal of publishing a set of distribution maps for all of the species in the state. In 1985, Tobey produced the first distributional atlas of Virginia's herpetofauna (Tobey, 1985; see review and corrections by Mitchell & Pague, 1986, 1987). Joe (often with his wife Wendy and one or more of their children) attended numerous VHS meetings over many years. At least one meeting per year consisted of formal talks and live animals, and often field trips. Joe credited the VHS with introducing him to research and science (Mitchell, 2019a). He served as VHS President from 1989–1993 and was the second editor (1982–1984) of the society's journal *Catesbeiana*. Through Joe's influence, the VHS became even more scientifically-based. He received a Lifetime Achievement Award from the VHS in 2007 for his many contributions to Virginia herpetology.

With nearly a decade (1983–1989) of financial support from the Virginia Department of Game and Inland Fisheries (VDGIF), Joe and his collaborator Chris Pague embarked on an intensive, statewide survey of Virginia's amphibian and reptile fauna with the goal of producing a book on the subject. They were assisted by a number of very capable, aspiring young biologists and naturalists, primarily Kurt Buhlmann and David Young, but also including Scott Stahl and Chris Hobson, This effort eventually resulted in the publication of Joe's book on the reptiles of Virginia (Mitchell, 1994), but a companion volume to the state's amphibian fauna was never produced, at least in part, because Chris Pague moved to Colorado in 1992 to work for The Nature Conservancy.

In 1989, Joe applied for the newly created position of Curator of Herpetology at the fledging Virginia Museum of Natural History (VMNH) in Martinsville, a job for which he was highly qualified. From 1985–1988, he had served on the museum's Scientific Advisory Board. Joe was devastated when he was not hired for the position, and was bitter about that result for many years. However, he eventually moved past that unfortunate situation and later in life considered it a positive outcome for his family and toward his subsequent career growth. Ironically, the chosen candidate left the state after 2–3 years and the museum has not had a herpetologist on its staff ever since. Despite his unpleasant experience with VMNH, Joe was a Research Associate of the museum for many years (1993–2019) and donated thousands of specimens of amphibians, reptiles, mammals, insects, and other invertebrates to the museum. He also wrote two popular articles on amphibians and reptiles for *Virginia Explorer*, the museum's now-defunct magazine. In May 2008, Joe received the Thomas Jefferson Medal for Outstanding Contributions to Natural Science from the VMNH Foundation in recognition of his many contributions to the study of herpetology and natural history in Virginia.

Following his failure to secure the VMNH position, Joe formed his own consulting business (Mitchell Ecological Services) in 1989, which thrived for several decades and was still in existence at the time of his death. His clients included various federal agencies (e.g., US Forest Service, US National Park Service, US Department of Defense, US Fish and Wildlife Service, Natural Resource Conservation Service), state agencies (Virginia Department of Game and Inland Fisheries, Virginia Department of Conservation and Recreation), private conservation organizations (e.g., The Nature Conservancy), and other private consulting firms. Many of his consulting jobs involved field work in Virginia, but some were as far away as California. His study sites in Virginia included such places as the Blue Ridge Parkway, Shenandoah National Park, Colonial National Historical Park, Prince William Forest Park, George Washington and Jefferson National Forests, Fort A.P. Hill, Fort Belvoir, Fort Story, Quantico Marine Corps Base, and Eastern Shore of Virginia National Wildlife

Joe Mitchell, 1980s (photo courtesy of Mitchell family).

Joe Mitchell with Snapping Turtle (*Chelydra serpentina*), mid-1980s (photo from *Richmond Times Dispatch* article).

Joe Mitchell searching for turtles in a partially drained reservoir, Newport News, Virginia, mid-1980s (Lynda Richardson photo).

Joe Mitchell shaking hands with Roger Conant, author of the *Peterson Field Guide to Reptiles and Amphibians of Eastern and Central North America*, at the joint annual meeting of the Society for the Study of Amphibians and Reptiles (25th anniversary meeting) and The Herpetologists' League, Raleigh, North Carolina, August 1982. Joe and Roger became good friends starting in 1989 at the First World Congress of Herpetology held in Canterbury, England (David Grim photo; courtesy of Joseph C. Mitchell).

Refuge. By his own account, Joe wrote 150 reports for clients containing >5,300 pages (Mitchell, 2019a). Some of these reports and data later formed the basis for papers and notes in scientific journals.

Joe was an excellent field herpetologist and a traditional natural historian. He worked on all groups of amphibians and reptiles, but he was especially fond of snakes and turtles. He conducted field work in the majority of Virginia's counties, perhaps even all of them. Among his many discoveries were several new state records, including Mabee's Salamander (*Ambystoma mabeei*) and Eastern Glass Lizard (*Ophisaurus ventralis*). Joe wanted to know about everything herpetological concerning Virginia, including who else was studying which species where. Gathering natural history data was the primary goal of his field work, as he generally disdained the development and testing of new theories or mathematical modelling exercises. Long before VDGIF created the position of "state herpetologist", Joe was the *de facto* state herpetologist. He could even be somewhat territorial in that regard, not always warmly welcoming out of state herpetologists into Virginia. However, he was very helpful and encouraging to many students and other young herpetologists, generously sharing information and ideas with them. Joe served on the graduate thesis committees of students at several universities (e.g., Virginia Tech, Christopher Newport University), but was a mentor to many other aspiring herpetologists and field biologists. He continued to mentor students and even some younger colleagues in Florida after he moved there in late 2007. Joe was an inspiration to many budding field biologists.

Beginning in 1974, Joe meticulously maintained a bibliography of publications pertaining to Virginia herpetology. He published his first compilation containing 875 references in 1981, which covered the period from English colonization of Virginia (early 1600s) to 1980. With funding from the Virginia Herpetological Society, Joe produced an updated, greatly expanded version (nearly 3,000 references) of the bibliography in 2017, thus culminating a 43-year project. This new bibliography is available on the VHS website and will be updated annually by members of the society.

Joe Mitchell's scientific publications span 46 years (1973–2019), with more to appear posthumously (e.g., Jacobsen et al., 2020). In his lifetime, Joe published >500 papers and eight books (see partial list below and Mitchell [2019a] for a more complete bibliography). These totals include 31 book reviews, 12 obituaries, and 38 published abstracts, the latter mostly based on presentations made at the annual meeting of the Virginia Academy of Science as well as several talks given at meetings of the Association of Southeastern Biologists. Between 1974 and 1997, Joe wrote 33 popular articles for *Virginia Wildlife* magazine pertaining to amphibians and reptiles, beginning when he was still an undergraduate student at VCU and at a time when these animal groups were less popular than they are today. He believed it was important to communicate to both the general public and other scientists about these taxa. As noted in Mitchell (2019a), he was informed years later by VDGIF that his first two popular articles (Mitchell, 1974a, b), which concerned the snakes of Virginia, were reprinted as a single article and distributed to >200,000 people over several decades, thus undoubtedly qualifying as his most widely read piece of literature.

Joe published or edited eight books, including *Reptiles of Virginia* (1994), *Amphibians and Reptiles of Assateague and Chincoteague Islands* (lead coauthor, 1994), *Atlas of Virginia Amphibians and Reptiles* (lead coauthor, 1999), *Urban Herpetology* (lead coeditor, 2008), *Salamanders of the Southeast* (lead coauthor, 2010), and the revised second edition of *Amphibians and Reptiles of the Carolinas and Virginia* (coauthor, 2010). In 1995, he received the Professional Award from the Virginia Chapter of The Wildlife Society in recognition of his book on Virginia reptiles. His salamander book, coauthored with Whit Gibbons, was named 2011 winner of the Outstanding Technical Title award by *Choice* magazine. At the time of his death, Joe was nearing completion of a coedited book (with Andy Holycross) on the snakes of Arizona, a project that had consumed much of his time during the preceding seven years. He enjoyed the chance to become involved in another project concerning the herpetofauna of Arizona, which was his second favorite state after Virginia and where he conducted his Master's thesis research in the desert. Joe also coauthored three popular guidebooks to Virginia's amphibians and reptiles, one of which (salamanders) will be published in 2020.

Joe published dozens of field notes on amphibians and reptiles covering a wide variety of topics, including maximum body and clutch sizes, reproduction, diet, predators, color abnormalities, deformities (limbs, shells, missing eyes, etc.), phenology, habitat, parasites, diseases, male combat in snakes, unusual behaviors, and noteworthy geographic distribution records. His philosophy was that each new bit of information published about a species contributed to the overall knowledge of it, and could lead to new questions or hypotheses. Joe also published several review papers, including those on cannibalism in reptiles, interspecific oophagy in reptiles, and keratophagy in reptiles (eating of shed skins). He published important papers on several rare or uncommon species of amphibians and reptiles based on extensive field work conducted in Virginia, including the Bog Turtle (*Glyptemys muhlenbergii*), Smooth Greensnake (*Opheodrys vernalis*), Tiger Salamander (*Ambystoma tigrinum*), Cow Knob Salamander (*Plethodon punctatus*), and Peaks of Otter Salamander (*Plethodon hubrichti*). In recent decades, he collaborated with various other scientists on several studies examining the prevalence of chytrid fungus in North American amphibians. He also published several papers on the herpetofauna of Virginia's Eastern Shore, including the barrier islands. Joe once admitted that he was driven to continually publish more papers, not only to increase our knowledge of the various species, but also to secure his own legacy. I believe he succeeded on both accounts. No one in the history of Virginia herpetology has made more important contributions than Joe Mitchell, and it is unlikely that they will ever be matched.

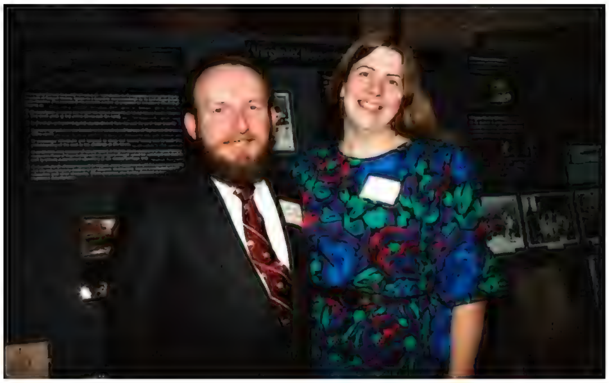
Joe became good friends with herpetologist Roger Conant (1909–2003) of Peterson Field Guide fame late (September 1989) in the latter's life (Mitchell, 2004). In 1991, Joe served as co-host of a symposium honoring Roger entitled "Conservation and Captive Husbandry of Amphibians and Reptiles" that was held at a national herpetological meeting. Joe reportedly promised Conant in 1993 that he would write a book on the herpetofauna of the Delmarva Peninsula based on Conant's field notes and data, and Joe's own observations from Virginia's Eastern Shore, but he was never able to do so. As noted in his brief autobiography (Mitchell, 2019a) written more than 25 years later and only a few months before his death, Joe said the Delmarva book had risen to the top of his "to do" list.

Most of Joe's papers concerned amphibians and reptiles, but he also coauthored more than a dozen papers that entirely or partially concerned Virginia mammals. Most of these papers were coauthored with John Pagels and Scott Bellows of VCU. Joe also coauthored two papers on beetles, one on vernal pool insects, and another on fish. During the 1970s, he published several papers encouraging biologists and naturalists to record and publish phenological observations and data, such as the first calling date of each year for local frogs and toads. I believe his pleas went largely unheeded, but such data would be valuable today in relation to studying the impacts of global climate warming on animal behavior and phenology.

In addition to his unrivaled contributions to Virginia herpetology, Joe Mitchell can also be considered the founding father of the Virginia Natural History Society (VNHS). In the late 1980s, he conceived of the idea of a new journal devoted to the natural history of Virginia at a time when he felt that few natural history papers were being published in the *Virginia Journal of Science* and other scientific journals (Mitchell, 1993). He shared his idea with longtime friend and colleague Richard Hoffman (1927–2012), Curator of Recent Invertebrates at the fledgling Virginia Museum of Natural History, who enthusiastically supported the idea and suggested the journal's name to honor John Banister, the first university-trained naturalist in Virginia. Joe and Richard were the founding coeditors of *Banisteria*, and, after much planning and discussions with similar-minded biologists/naturalists, including Barry Knisley, Michael Kosztarab, and Tom Wieboldt, they produced the first issue of *Banisteria* in November 1992 to coincide with the 300th anniversary of Banister's accidental death. Besides his own initial contributions, Joe helped write several articles for others that appeared in the inaugural issue of *Banisteria*. He contributed papers to most of the *Banisteria* issues published during the next quarter century, and remained a coeditor through 2007. The following year Joe was recognized as an Honorary Councilor of VNHS, a status he retained until his death.

Through 2019, Joe Mitchell and various coauthors published 62 papers in *Banisteria*, including 30 regular contributions, 30 shorter contributions (notes), and two historical papers. He had many more potential *Banisteria* manuscripts in mind or rough draft. Only Richard Hoffman's total contributions (83) exceed those of Joe for the most by any author. Joe also wrote five obituaries and seven book reviews for *Banisteria*. He also contributed to the Virginia Natural History Society in other significant ways. He played major roles in helping to plan and organize all three symposia sponsored or cosponsored by VNHS to date, including the Big Levels: Shenandoah Valley Sinkhole Ponds and St. Mary's River Symposium in October 1998 (lead organizer and coeditor of the proceedings published in *Banisteria* 13; see Mitchell et al., 1999), Richard Hoffman's 80th birthday symposium in September 2007 (cosponsored by VMNH and VNHS; Joe and I coedited Dr. Hoffman's Festschrift volume, which was published two years later by VMNH [Roble & Mitchell, 2009]), and the September 2009 VNHS symposium entitled "Historical Explorations into Virginia's Natural History" (several presentations were published in *Banisteria* 41; see McAvoy, 2013). The VNHS owes its existence to Joe's vision and his dedication over many years.

Joe had a strong interest in the history of natural history, especially as it related to herpetology or Virginia. He published papers concerning the contributions of Emmett Reid (E. R.) Dunn, Richard Hoffman, James Organ, and Frank Tobey, among others, to Virginia herpetology, and discussed the efforts of Leslie Burger in his *Reptiles of Virginia* book. In recent years, Joe coauthored several papers concerning the history of the journal *Copeia* and its namesake Edward Drinker (E. D.) Cope. He had plans to prepare several more historical papers. As of 2018, Joe was the editor



Joe and Wendy Mitchell at the Virginia Museum of Natural History, 1988 (photo courtesy of Mitchell family).

Joe Mitchell and Kurt Buhlmann photographing a Many-lined Salamander (*Stereochilus marginatus*) during a Virginia Herpetological Society field survey, Cypress Swamp, Surry County, April 28, 1991 (Mike Hayslett photo).

Original members of the Executive Committee of the Virginia Natural History Society at their December 1993 board meeting at Hampden-Sydney College: left to right: Barry Knisley, Tom Rawinski, Joe Mitchell, Richard Hoffman, Anne Lund, Dick Neves, Michael Kosztarab (photo courtesy of Michael Kosztarab).

Joe Mitchell holding a neonate Corn Snake (*Pantherophis guttatus*), New Jersey Pine Barrens, September 28, 1999 (Robert Zappalorti photo).

Joe Mitchell with Copperhead (*Agkistrodon contortrix*), early 2000s (photo courtesy of Mitchell family).

Banisteria coeditors Richard Hoffman (1992-1999), Joe Mitchell (1992-2007), and Steve Roble (2000-2019) at Dr. Hoffman's 80th birthday symposium, Virginia Museum of Natural History, September 22, 2007 (Arthur V. Evans photo).

of *Bibliotheca Herpetologica*, a publication of the International Society for the History and Bibliography of Herpetology.

Joe constantly encouraged others to publish their natural history observations, including student theses that were "gathering dust on bookshelves", in journals such as *Banisteria*, but was disappointed that so few heeded his pleas. He uttered the phrase "If it ain't published, it didn't happen" on multiple occasions. Joe was a strong advocate for classical natural history and was not impressed by high-powered statistics or modelling. The emphasis of the early part of his career was directed toward gathering observations and data pertaining to the natural history of amphibians and reptiles, particularly the fauna of Virginia, but in the latter half he increasingly devoted more of his efforts toward the conservation of these organisms that he cared for and so deeply loved. However, learning more about their natural history always remained very important to him because he believed it was critical to species and habitat management and conservation.

Joe was a strong supporter of natural history museums and their collections. He believed in the value and importance of preserved voucher specimens as the best form of documentation for a variety of purposes, including geographic distribution records, studying reproductive cycles, food habits, morphological variation, and taxonomy and systematics. He often stressed the need to collect series of specimens, not just one individual per locality. Joe and his field crews conducted extensive pitfall trapping in Virginia, which yielded thousands of specimens of amphibians, reptiles, mammals, and invertebrates, and resulted in many papers by Joe and various coauthors. Other researchers have cited his insect specimens, especially beetles, in their papers (e.g., various papers by Richard Hoffman; also Harden, 2018). Joe's donations of amphibians and reptiles include about 26,000 specimens to the National Museum of Natural History (Smithsonian Institution, Washington, D.C.), 6,000 to the Carnegie Museum of Natural History (Pittsburgh, PA), 2,700 to the Virginia Museum of Natural History (Martinsville, VA), and 1,475 to the North Carolina Museum of Natural Sciences (Raleigh, NC). He also rescued about a dozen orphaned collections from institutions that would have otherwise disposed of their specimens. Joe's natural history collections will be used by researchers for many years to come. Some recent studies, such as that of Hughes et al. (2017) which concerned reproduction and growth of Southern Leopard Frogs in Virginia, relied in large part on specimens obtained during pitfall trapping by Joe and his colleagues, especially Kurt Buhlmann and Chris Pague. Joe was not especially thrilled to learn that some out of state researchers were studying "his" specimens in the Carnegie collection, but he was resigned to the fact that he had too many unfinished projects of his own and would need another lifetime to gather all the natural history data he desired from his collections. Therefore, he accepted the reality that other herpetologists could learn and publish from their examination of those specimens.

Seemingly, Joe never met an amphibian or reptile that he didn't want to measure, weigh, determine its reproductive status, examine for parasites and abnormalities, etc. He also collected many roadkills to obtain information on their diets, etc. Joe recorded voluminous amounts of data on Virginia's amphibians and reptiles, perhaps never to be surpassed by anyone. Much of the data he obtained on reptiles through the early 1990s were summarized in his 1994 book on the state's reptile fauna. During the past decade, Joe began to publish some of the amphibian data collected many years ago with Chris Pague, acknowledging that there was an ever decreasing chance that he would someday have the time and energy to prepare a book on Virginia's amphibians. These papers include a detailed study of the comparative geographic distributions of the sibling species pair of gray treefrogs (*Hyla chrysoscelis* and *H. versicolor*) in the state, as well as the collective data gathered by Joe and Chris on clutch size for 21 species of Virginia frogs and toads.

Joe Mitchell was an early, longtime, and influential leader in the effort to conserve amphibians and reptiles in Virginia. In 1987, he and Chris Pague coauthored two papers on the conservation status of amphibians and reptiles in the *Virginia Journal of Science* (separate papers for each Class). They were written at a time when herpetological conservation was still a rather novel concept and much less embraced than it is today. Joe was chair of the VDGIF herpetology advisory committee for many years and edited the book chapter and wrote or coauthored most of the amphibian and reptile species accounts resulting from the 1989 symposium on endangered and threatened species in Virginia (Terwilliger, 1991). In collaboration with VDGIF "non-game" staff, Joe played a key role in developing state recovery plans for several endangered or threatened amphibians and reptiles, typically drafting the plan and serving as the lead author. He received an award certificate from VDGIF in 1993 for his efforts related to amphibian and reptile conservation in Virginia. Joe and colleague Kurt Buhlmann worked with the US Forest Service (George Washington National Forest [GWNF]) on the biology and conservation of a disjunct population of the state endangered Tiger Salamander in the Shenandoah Valley following its discovery in 1987 by Kurt and Richard Hoffman (Buhlmann & Hoffman, 1990). About a decade later, Don Church conducted an intensive study of this population for his dissertation research at the University of Virginia (Church, 2004). Joe, Kurt, and Chris Pague conducted extensive surveys for the Cow Knob Salamander on GWNF lands in northwestern Virginia, as well as for the Peaks of Otter Salamander on the Jefferson National Forest and adjacent Blue Ridge Parkway lands. Joe and Kurt also worked with the National Park Service to survey for Bog Turtle populations along the Blue Ridge Parkway.

In the early 1990s, Joe took the lead on developing conservation agreements for the Cow Knob Salamander and Peaks of Otter Salamander between the US Fish and Wildlife Service, US Forest Service, and the National Park Service. These documents, which were signed in 1994 and 1996, respectively, were developed as an alternative to having both species added to the federal list of endangered and threatened species by the US Fish and Wildlife Service. Joe received an award from the US Forest Service in recognition of his efforts to prepare the Cow Knob Salamander agreement. Subsequently, Billy Flint of James Madison University has conducted numerous additional surveys for the Cow Knob Salamander, which have helped to better define its range. Likewise, Paul Sattler, Norm Reichenbach, and Jill Wicknick have studied the Peaks of Otter Salamander, especially its response to various timber harvesting practices. Joe collaborated with Jill and Carl Anthony on some of their research on this species.

Joe was the lead author (with seven others, including me) of a 1999 paper on the conservation status of the Appalachian herpetofauna. He also authored or coauthored papers concerning the impact of feral cats on wildlife, especially amphibians and reptiles, snake entanglement in mesh landscape netting, the value of restored wetlands to amphibians and reptiles, and the role of burrows as thermal refugia. He also compared the amphibian and reptile communities of burned versus unburned habitats, as well as changes in amphibian and small mammal communities following defoliation of their forest habitat by the larvae of exotic gypsy moths (*Lymantria dispar*). Joe contributed species accounts or chapters to a number of books edited by others, including 11 species accounts for Lannoo's (2005) book on the conservation status of all North American amphibians. The topics of his other book chapters included herpetological sampling methods, habitat fragmentation, ecology and management of riparian habitats for amphibians and reptiles, the importance of vernal pools to reptiles, birds, and mammals, the effect of sprawl on amphibians, reptiles, and other taxa with limited dispersal abilities, and frog and toad life histories.

During the past two decades, Joe was heavily involved with Partners in Amphibian and Reptile Conservation (PARC), a group formed in 1999 and modeled after the successful Partners in Flight program for bird conservation. Joe coauthored habitat management guidelines for two of the five PARC regions in the US (Northeast, Southeast) and served as coeditor for similar publications for the other three regions (last one was published in 2016). These documents were written for managers of public and private land, private landowners, and other interested parties and were essentially "How to" manuals for providing and managing good habitat for amphibians and reptiles. Joe considered the PARC habitat management guidelines to be among his most important contributions to herpetology (Mitchell, 2019a). Joe and his coauthors of the Southeast guide were honored in 2007 by the Florida Chapter of The Wildlife Society. Joe regarded PARC as "the Marines of herp conservation." He was also involved with several turtle conservation groups, including the Turtle Survival Alliance, Gopher Tortoise Council and, since 1987, was a member of the International Union for Conservation of Nature's (IUCN) Tortoise and Freshwater Turtle Specialist Group. In August 2019, Joe posthumously received the Turtle Conservation Appreciation Award from the latter organization for his many contributions to turtle biology and conservation. He was also a member of two other IUCN specialist groups: Declining Amphibian Populations (since 1998) and Amphibians (since 2006). From 1994–2001, Joe was co-chair of the Appalachian Working Group of the Species Survival Commission's Declining Amphibian Populations Task Force.

Perhaps to a fault, Joe was overly ambitious at times, taking on new projects, whether in terms of field work or writing (e.g., books), that prevented him from finishing some other current task or project in a timely manner, if at all. This sometimes created undue stress on his health. Besides the Delmarva herpetology book with coauthor Roger Conant mentioned previously, Joe did not complete at least two other books to which he had devoted considerable time and energy. After his collaborator Chris Pague moved to Colorado in 1992, responsibility for their proposed "Amphibians and Reptiles of Virginia" book fell entirely upon Joe. To his credit, Joe succeeded in completing and publishing the reptile portion in 1994 as an excellent, stand-alone book, but he was never able to find the time and energy to produce a comparable manuscript on the amphibians. I have little doubt that Joe would have written that book, or perhaps a single book covering all amphibians and reptiles of Virginia, if he had been hired by VMNH in 1989. Also, perhaps unbeknownst to many, Joe and the late Andrew "Andy" Price (1951–2012; Mitchell & Hodges, 2012), a biologist for the Texas Parks and Wildlife Department, had a contract with Cornell University Press to produce the definitive "Natural

History of North America Snakes" book (not exact potential title) early in the 21st century. They researched and worked on the manuscript for at least five years but missed various deadlines for its submission. Ultimately, the press hired a new science editor who informed Joe that they were no longer interested in publishing the book. Joe and Andy had compiled between 1,000 and 2,000 references pertaining to the biology and natural history of North American snakes, including numerous obscure papers unearthed by Andy, but they made no further progress on its completion due to the lack of a publisher and Andy's declining health and eventual death. A few years ago, Joe suggested that he might place the bibliography on-line (in searchable format) to make the fruits of their labor available to others, but to my knowledge that has not happened and I am not aware of any current plans to do so.

Joe was a lifetime member of several national/international herpetological societies, including The Herpetologists' League (HL), American Society of Ichthyologists and Herpetologists (ASIH), and the Society for the Study of Amphibians and Reptiles (SSAR). He was proud of his long-term service to these and other professional herpetological societies and greatly valued the friendships he forged with numerous herpetologists over many decades. He considered the collective community of herpetologists as "my tribe" (Mitchell, 2019a). Joe made many friends through his attendance at their annual meetings and collaboration on research and book projects with others.

Joe attended dozens of national herpetology meetings and several World Congresses of Herpetology spanning more than four decades. He served on the board of The Herpetologists' League for 20 years including as Secretary from 1986–1995 and President in 1998–1999. His service to SSAR included Geographic Distribution section editor for *Herpetological Review* (1975–1979). Since 2007, Joe had been the editor of the SSAR publication series *Herpetological Conservation* and was nearing completion of the next volume at the time of his death. He served on the Board of Governors for ASIH from 1996–2001. For the past 15 years, he thoroughly enjoyed being the society's Herpetology Historian. In this role, he interviewed distinguished senior herpetologists about their lives and careers and prepared biographies for the "Historical Perspectives" section of *Copeia*. Perhaps the last publication during his lifetime was the sixth such biography that he authored or coauthored (Mitchell, 2019b). I suspect that he had interviewed several other senior herpetologists but had not yet finished or written their biographies. Joe also served on the editorial boards of the journals *Amphibian and Reptile Conservation*, *Herpetologica*, and *Herpetological Natural History*.

Joe Mitchell was a longtime friend and colleague that I had known for at least 35 years. I don't recall when we first met, perhaps at the joint meeting of the Society for the Study of Amphibians and Reptiles (25th anniversary meeting) and The Herpetologists' League in Raleigh, North Carolina, in August of 1982, but certainly no later than when Joe and Chris Pague visited the Section of Amphibians and Reptiles at the Carnegie Museum of Natural History (where I worked at the time) in Pittsburgh in late 1983 or early 1984. Joe was excited to learn via the late Jack McCoy (Carnegie herpetology curator) that I was moving to Richmond in June 1992 to succeed Chris as the Staff Zoologist for the Virginia Department of Conservation and Recreation's Division of Natural Heritage.

Joe and I both had strong interests in traditional natural history and organismal biology and a close mutual friendship with Richard Hoffman (Joe much longer than me) of the Virginia Museum of Natural History, who was an inspiration to both of us because of his vast knowledge, high productivity, humility, and strong passion for Virginia natural history. From 2000–2007, Joe and I served as coeditors of *Banisteria* after I succeeded Richard in that role. We got off to a bit of a rocky start when Joe felt that my review of one of his papers was unduly harsh, but we got past that issue and enjoyed a good working relationship thereafter. When Joe moved to Florida in the fall of 2007, I became the sole editor of *Banisteria*. I very much appreciated the compliments that I received from both Joe and Richard on each new issue of *Banisteria* that I produced. Joe and I also coedited a Festschrift volume (2009) in honor of Dr. Hoffman. I became a better writer and editor through my interactions with Joe. Both he and Richard repeatedly encouraged others to publish their natural history data rather than let it gather dust in notebooks or theses, but too often to no avail. Joe was quite persistent and usually successful in getting authors to contribute manuscripts to the multi-authored books that he edited, including a volume entitled *Urban Herpetology* and the still to be published book on Arizona snakes.

Joe and I also shared a strong belief in the importance of voucher specimens and the value of natural history collections. Although we did not spend much time in the field together, I have fond memories of several late winter nocturnal surveys with Joe and others to observe and study breeding activity in the disjunct population of Tiger Salamanders in the Shenandoah Valley. Besides preparing Richard Hoffman's obituary (different versions for *Banisteria* and *Catesbeiana*) in 2012, Joe and I only coauthored two papers together, but had recently discussed finally preparing a paper on the herpetofauna of a state natural area preserve that has languished for more than 20 years.

Joe Mitchell family, September 24, 2006: front row, left to right: Tanya Shewmake and daughter Allison; Joe Mitchell, Lisa Mitchell; back row: Stephen Shewmake, Justin Mitchell, Joshua Mitchell (photo courtesy of Mitchell family).

Mark Bailey, Kurt Buhlmann, Jeff Holmes, and Joe Mitchell, recipients of the Paul Moler (second from right) Herpetological Conservation Award, Florida Chapter, The Wildlife Society, April 2007 (photo courtesy of Susan Walls).

Joe Mitchell and Whit Gibbons, longtime colleagues and coauthors of *Salamanders of the Southeast* (Kurt Buhlmann photo).

Joe Mitchell with longtime friend, colleague, and fellow herpetologist Kurt Buhlmann, whom Joe mentored early in his career, May 7, 2009 (photo courtesy of Kurt Buhlmann).

Joe Mitchell and wife Susan Walls at the Joint Meeting of Ichthyologists and Herpetologists, New Orleans, July 2006 (Ken Dodd photo).

Joe Mitchell with Slider (*Trachemys scripta*), Santa Fe River, Florida, 2013 (Georgia Shemitz photo).

Since my arrival to Virginia more than 27 years ago, Joe and I had many discussions about herpetology and natural history in general, the status and future of *Banisteria* and the Virginia Natural History Society as well as the Virginia Herpetological Society and its journal *Catesbeiana* (for which I served as editor from 1998–2007), our mutual admiration of and friendship with Richard Hoffman, the ups and downs of Joe's personal and professional life, etc. As noted by Dodd (2019), Joe could become quite animated when speaking about certain topics of great interest to him, but he was also very opinionated about other issues or ideas, strongly disagreeing with some colleagues or other researchers on occasion. This did not always endear him to some. From my perspective, Joe certainly "mellowed" during the last 15 or so years of his life, seemingly becoming more relaxed, friendly, and humble, and leading a less stressful life. I recall that he took some banjo lessons and was involved with a choral singing group, but I never asked if he continued with either for very long. He also took up his hobby of woodworking again, at which he was quite accomplished.

Joe lived in Richmond for most of his life, but moved to Florida in the fall of 2007 where his wife Susan Walls had recently relocated from Louisiana. Despite the move, Joe always felt that he was a Virginian/ Richmonder. With each passing year, Joe had a less intimate knowledge of all things herpetological in Virginia, particularly new research projects conducted by others, and he rarely attended VHS meetings during the past decade. After his relocation, Joe soon learned that there were no empty niches for consulting herpetologists in Florida. As he freely admitted to friends and colleagues (and mentioned in his autobiography), he didn't realize how much his identity was tied to Virginia. It was difficult for Joe to obtain contract jobs in some years during the past dozen or so, and in other years some of his field work was conducted far from his Florida residence, including North Carolina, Virginia, and more distant states. He drove cross country (as far as California) three times during the 2009 field season as part of a widespread survey of chytrid fungus prevalence in amphibians on various military bases. This resulted in considerable stress to Joe and he suffered a heart attack late that year, soon followed by triple bypass surgery. Somehow, Joe managed to get permission from his doctor to bring his personal camera into the operating room, where a member of the surgical team took two photos of his heart. He intended to post them on social media and his wall "… to prove that I sometimes have a heart," but reconsidered because the images reminded him too much of the pain associated with the surgery (Mitchell, 2019a).

Joe eventually became affiliated with the Florida Museum of Natural History in Gainesville, first as a volunteer, but then was later (2016) appointed a Research Associate of the museum. He edited one herpetologically-themed issue of the *Bulletin of Florida Museum of Natural History* in 2016. During his residency in Florida, Joe collaborated on turtle research projects with Jerry Johnston of Santa Fe College in Gainesville, resulting in more than 20 scientific papers and notes (see partial list in the bibliography below).

Since his move to Florida, Joe rarely visited Richmond except to visit family at least once a year. On several of those occasions, I had lunch with Joe and Barry Knisley, the latter also a longtime, strong supporter of the Virginia Natural History Society, including serving two terms as President more than a decade apart. Their relationship dates back to the early 1980s when Joe mentored Barry's undergraduate student at Randolph-Macon College with lizard feeding experiments in Arizona and Virginia (McGovern et al., 1984, 1986). Once again, the current status and future of natural history and field biology were central themes of our discussions.

In his last few years, Joe enjoyed a semi-retired life on the six-acre property that he shared with his wife Susan and their dogs in rural North Florida. He was still actively writing scientific papers and editing. In 2019, he had also been subcontracted by a Jacksonville consulting firm to conduct herpetological surveys at several naval bases on the East Coast, including Fort Story in Virginia Beach, where his last field days in Virginia were spent.

At the time of his death, Joe had many more papers on Virginia herpetology planned but not finished or even started, of which I am aware of only a few. He had voluminous amounts of unpublished data, which will hopefully be archived for use by other researchers in the future. Despite his short stature (5'3"), Joe Mitchell was a giant in Virginia natural history. He held the torch for Virginia herpetology for many decades during a period when the study and appreciation of amphibians and reptiles were less popular than they are today; he was the "go to" person on all matters related to that subject. His contributions to Virginia herpetology will never be matched: publications, mentorship, field skills, getting the word "conservation" in the same sentence as "amphibians and reptiles," etc. His vision and leadership in creating *Banisteria* and the Virginia Natural History Society were also significant feats.

Like many others, my immediate reaction to the news of Joe's sudden death was one of shock and disbelief. His passing was difficult to accept and represents a great personal loss. He was an accomplished scientist, naturalist, conservationist, teacher, mentor, editor, colleague, and friend to many, including me. He left many lasting contributions to the fields of herpetology and conservation in Virginia and beyond and firmly secured his place in the annals of Virginia natural history. He will be sorely missed by his family and his many friends inside of and beyond the herpetological community.

Joe is survived by his wife, Dr. Susan Walls of Fort White, Florida; four children, Tanya Shewmake with first wife, Ginny Meeks; Joshua, Justin, and Lisa Mitchell with second wife, Wendy Robertson; two grandchildren, Allison and James Shewmake; two brothers, Ron (Karen), Allen (Patti); sister, Susan Johnson; and numerous cousins, nieces, and nephews. He was preceded in death by his parents, Kathleen and Calvin Mitchell, and brother-in-law, Billy Johnson. A memorial service for Dr. Mitchell was held on August 3, 2019, in Richmond (Mechanicsville), and an outdoor celebration of his life and career followed on August 18, 2019, beside a spring-fed tributary to the Santa Fe River near High Springs, Florida. Charitable donations in Joe's memory may be made to the American Heart Association, Alzheimer's Foundation, the Amphibian and Reptile Conservancy or The Center for Biological Diversity. Dodd (2019) recently published another obituary for Dr. Mitchell that includes additional information about his life and career, as well as personal reflections from several colleagues.

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Partial List of Publications by Joseph C. Mitchell

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Obituary

Oliver S. Flint, Jr.
(1931-2019)

Dr. Oliver ("Ollie") Simeon Flint, Jr., world renowned expert on caddisflies, died on May 18, 2019, at the age of 87 after a prolonged period of gradually declining health. A longtime resident of Alexandria, Virginia, he was born on October 10, 1931, in Amherst, Massachusetts. Ollie grew up on the same street where the renowned dipterist Charles P. Alexander (1889–1981) resided. Alexander was the author of >11,000 insect descriptions (Knizeski, 1979; Byers, 1982; Oosterbroek, 2009), primarily of crane flies (Tipuloidea), including three patronyms for Ollie (Alexander, 1961, 1967, 1970). In his youth, Ollie mowed the professor's lawn. Alexander became his entomological mentor and many years later (1981), he sold his enormous insect collection (>13,000 species and 55,000 slides; Oosterbroek, 2009) and library to the Smithsonian Institution's National Museum of Natural History, at least in part because of his great respect for Ollie's accomplishments as a curator and research scientist there.

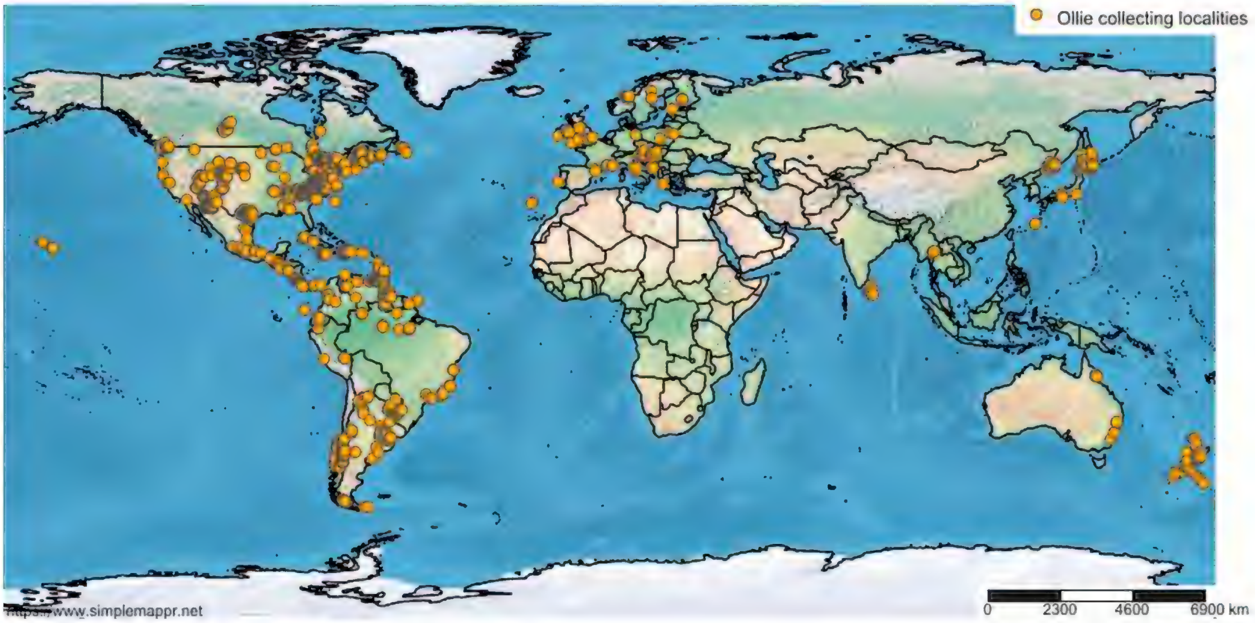
After graduating from high school, Ollie remained in Amherst and enrolled at the University of Massachusetts, where he obtained a B.S. in Biology in 1953 (*magna cum laude* and departmental honors). Two years later, he obtained a M.S. degree in biology from that same institution under the direction of Marion E. Smith (191?–1988), a colleague and former student of Alexander who studied Diptera (primarily mosquitoes) and Lepidoptera. Ollie's Master's thesis was titled "The life history and biology of the genus *Frenesia* (Trichoptera: Limnephilidae)" and was published a year later in the *Bulletin of the Brooklyn Entomological Society* (Flint, 1956). It was the first of his many papers on caddisflies. Ollie pursued further study in the Department of Entomology and Limnology at Cornell University, where he earned a Ph.D. in 1960 under the direction of Clifford O. Berg (1912–1987), who studied sciomyzid flies and snail-borne diseases, being the first to discover that fly larvae prey on snails (Brown et al., 2010). Ollie was a National Science Foundation Predoctoral Fellow at Cornell from 1957–1959. His 264-page dissertation, entitled "Taxonomy and biology of Nearctic limnephilid larvae (Trichoptera) with special reference to species in eastern United States" was published in 1960 in *Entomologica Americana*. Because of his expertise in the fields of entomology, botany, and geology at an early age, Ollie had been offered graduate fellowships in all three disciplines, but chose the former for his career. However, he maintained his interests in botany and geology throughout his lifetime, and became quite knowledgeable of tropical botany.

In 1961, Ollie was hired as an Associate Curator of Entomology by the National Museum of Natural History (NMNH), Smithsonian Institution, in Washington, D.C. He assumed responsibility for a relatively small collection of Neuropteroid insects that was previously cared for by Sophy I. Parfin (1918–1966), who specialized in the order Neuroptera (Gurney & Walkley, 1967). His duties were to curate and do research on the "smaller insect orders", especially the "Neuropteroids." He was promoted to Curator in Charge of Aquatic Insects and Neuropteroids in 1965 and retired at the end of 1995 after 35 years of employment as a Smithsonian scientist. The collection experienced tremendous growth during Ollie's tenure, largely as a result of his own worldwide field work. He was appointed Curator Emeritus in 1996 and continued to collect, curate, identify, and publish for more than two additional decades (Fig. 1), often visiting the museum until the last six months of his life. No successor has been hired to fill his position since his retirement.

Ollie was a knowledgeable and dedicated curator, who took great pride in the quality, quantity, organization, and geographic coverage of the collections under his care. He had an excellent memory, a prerequisite of a good taxonomist and museum curator. His primary curatorial duties at the Smithsonian included five orders of aquatic insects (Ephemeroptera [mayflies], Odonata [dragonflies and damselflies], Plecoptera [stoneflies], Megaloptera [dobsonflies, fishflies, and alderflies], and Trichoptera [caddisflies]) and three orders of primarily or exclusively terrestrial insects (Neuroptera [lacewings, owlflies, antlions, mantisflies, spongillaflies, and relatives], Raphidioptera [snakeflies], and Mecoptera [scorpionflies]). Collectively, these orders currently account for more than 12,000 species and almost 400,000 specimens in the Smithsonian collection (Dikow, 2019). Ollie was also briefly responsible for the mosquito, louse, and flea collections. The Trichoptera collection is regarded as the most comprehensive, best curated, and most studied of its kind in the world, with its greatest strength being the Neotropical fauna. It includes vast numbers of both pinned and alcohol-preserved specimens of caddisflies that are well labelled and organized and easily accessible to visitors. The Smithsonian Odonata collection is also among the largest in the world, and is considered the best curated insect collection at that museum because it is both databased and well organized (nearly all specimens are stored in clear envelopes with 3 x 5 inch cards and housed in cardboard boxes). The type specimens of all orders under Ollie's care are also databased. A published summary (Flint, 2002) of the Smithsonian Neuropterida collection accounts for about 132 species of Megaloptera, 1,192 species of Neuroptera, and 33 species of Raphidioptera housed in 221 insect drawers (pinned adult specimens) and 311 bottles of vials (alcohol-preserved specimens of various life stages).

Ollie was a tireless collector (Fig. 2). He would often collect both day and night, searching for insects such as caddisfly larvae and dragonfly and damselfly adults by day and running ultraviolet lights after dark for nocturnal insects, especially adult caddisflies. He was fond of using a long-handled tropics net (Fig. 3) and was known among his colleagues for his unique technique of using his shirt pocket to properly pin caddisflies. Ollie conducted field work and collected insects on all continents (at least 45 countries; map 1) except Africa, including a midge on Antarctica (Dikow, 2019). He contributed countless thousands of insect specimens belonging to at least 14 orders to the Smithsonian collection. While the majority of these were caddisflies, he also added >26,000 specimens of Odonata from numerous countries worldwide (including 8,000 from North America) to the collection (Dikow, 2019). Ollie collected many undescribed species of insects during his career, and was often accompanied in the field by his wife Carol (Fig. 4), who also collected and recorded field notes. Many type specimens of Trichoptera and other insects bear their collecting labels.

Ollie and Carol served as warm, gracious hosts to many Smithsonian visitors for nearly a half century, including colleagues and students from all over the world, as well as local visitors such as me. I made dozens of visits to the Smithsonian during the past quarter century, usually day trips, and spent time with Ollie on most of those visits (Fig. 5). The Flints also invited me to stay at their residence on overnight trips. Ollie mentored students of both Trichoptera (mostly) and Megaloptera, generously sharing his vast knowledge, expertise, and collections.



Map 1. Oliver Flint's worldwide insect collecting localities include at least 45 countries on all continents except Africa (Courtesy of Erin Kolski and Torsten Dikow, Department of Entomology, National Museum of Natural History, Smithsonian Institution).

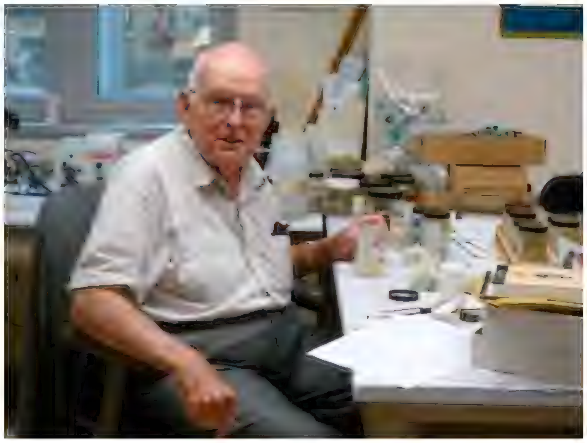


Fig. 1. Ollie Flint in his Smithsonian office, March 16, 2012 (William L. Murphy photo).

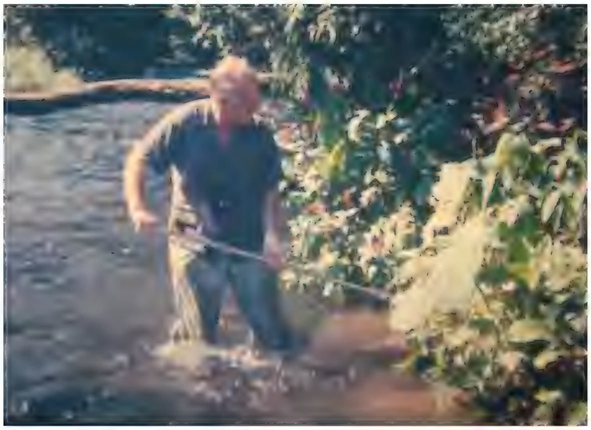


Fig. 2. Ollie Flint sampling aquatic plants for larvae of the caddisfly genus *Macronema* at Laguna Escondida in Los Tuxlas, Veracruz, México, December 1975 (Joaquin Bueno-Soria photo).

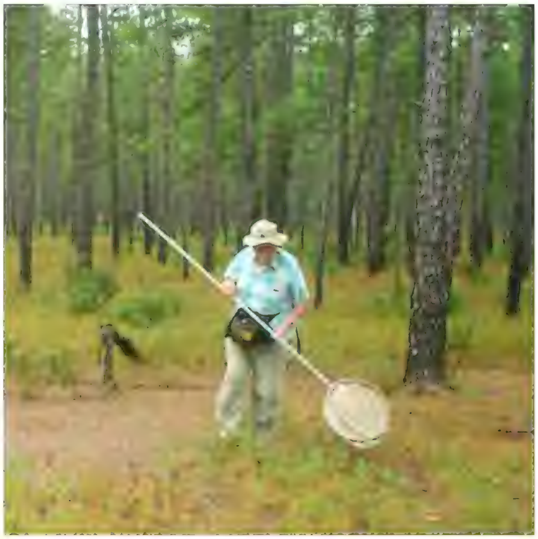


Fig. 3. Ollie Flint searching for the scorpionfly *Panorpa lugubris* at Blackwater Ecological Preserve, Isle of Wight County, Virginia, September 23, 2008 (Arthur V. Evans photo).

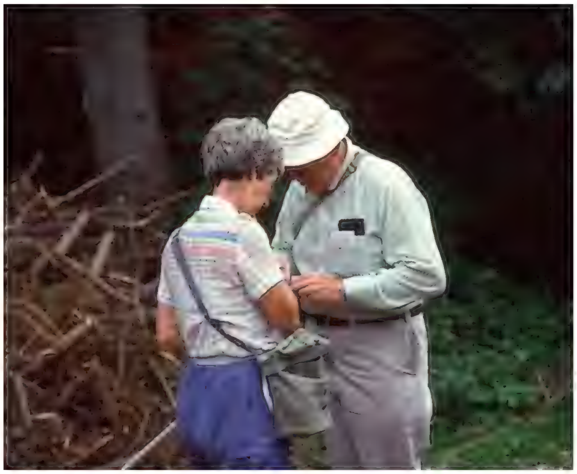


Fig. 4. Ollie and Carol Flint sorting and retrieving caddisfly adults after sweepnetting on a field trip during the 5th International Symposium on Trichoptera held in Lyon, France, July 23, 1986 (Henri Tachet photo).

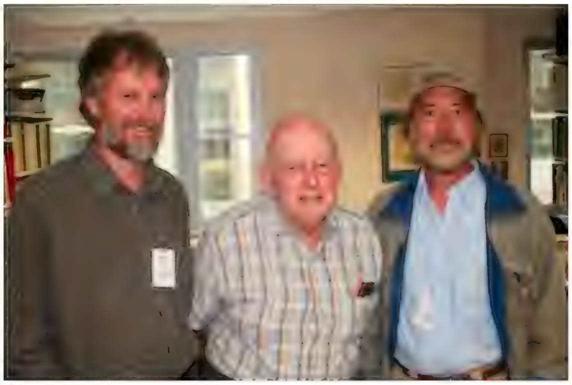


Fig. 5. Steve Roble, Ollie Flint, and Paul Bedell in Ollie's Smithsonian office, October 8, 2009, two days before his 78th birthday (Arthur V. Evans photo).

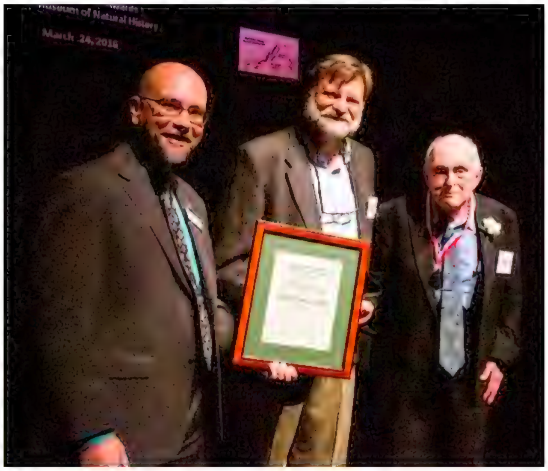


Fig. 6. Joe Keiper (Director, Virginia Museum of Natural History [VMNH]), Arthur Evans (presenter), and Ollie Flint (recipient of the Thomas Jefferson Medal for Outstanding Contributions to Natural Science) at the VMNH Foundation's 29th annual awards ceremony, Waynesboro, Virginia, March 24, 2016 (photo courtesy of VMNH).

Collectively, the Flints have been honored by nearly 90 colleagues worldwide through their descriptions of at least 102 patronyms, including three genera (*Flintiella* Angrisano, 1995; *Osflintia* Calor & Holzenthal, 2008 [both Trichoptera]; *Flintoconis* Sziráki, 2007 [Neuroptera]) and 99 species, in at least 11 insect orders (J. C. Morse, unpub. data; list available at Dikow, 2019). Slightly more than half of these taxa are caddisflies, including two genera and 53 species from all continents except Antarctica (Morse, 2019). Six caddisflies bear the specific epithet *carolae* in Carol's honor, including two described by Ollie. Two damselflies and four dragonflies, from South America, Mexico, Sri Lanka, and China, are named in honor of Dr. Flint (Garrison & von Ellenrieder, 2016; Hämäläinen, 2016; Schorr & Paulson, 2019). Among the nine stoneflies named in his honor are two North American species that he first collected in Virginia, *Acroneuria flinti* Stark & Gaufin, 1976 and *Megaleuctra flinti* Baumann 1973 (Table 1). The former remains known only from the female holotype specimen (Kondratieff & Kirchner, 1991).

Ollie was widely respected internationally for his worldwide expertise and lifetime scholarly work on the systematics of caddisflies (Trichoptera), especially the Neotropical fauna. He published about 250 papers, most of them containing descriptions of new species of insects, including >1,200 caddisflies (~7.5% of the known world fauna [>16,000 extant species; Morse, 2019]), as well as new species of dobsonflies, fishflies, alderflies (all Megaloptera), and spongillaflies (Neuroptera: Sisyridae). He also described one new family and 23 new genera (12 in the family Hydroptilidae) of caddisflies (Holzenthal et al., 2007; Morse, 2019), as well as the larval stages of many caddisfly species. His initial interest in caddisflies was focused on their larvae, of which he described many, but most of his career was devoted to the collection and description of the adults of new caddisfly species. In perhaps the last paper published during his lifetime, Ollie and his coauthors synonymized the Neotropical caddisfly family Anomalopsychidae, which he had described nearly four decades earlier (Flint, 1981), with the monotypic Australian family Antipodoeciidae (St Clair et al., 2018). Regrettably, Ollie did not live long enough to prepare the description of an apparently new species of *Pycnopsyche* (near *flavata* [Banks, 1914]) that I collected in southwestern Virginia in 2012 – he kept hoping that I would succeed in obtaining additional specimens before proceeding with its description.

Along with his late colleague Glenn Wiggins (1927–2013) of the Royal Ontario Museum in Toronto, Ollie was a major early contributor to an effort to summarize the state and provincial distributions of all North American species of Trichoptera. They shared their collective data with John Morse of Clemson University, who had also independently begun a similar effort. This eventually led to the creation of a continuously updated document that includes the state and provincial distribution of every species, along with the sources reporting each species from each jurisdiction (Rasmussen & Morse, 2018). With regard to the caddisfly fauna of Virginia, Ollie described 19 of the 374 species that inhabit the state, including seven that have Virginia type localities (Table 2). One of these species, *Ceraclea ruthae* (described in the genus *Athripsodes*), was named for his first wife Ruth (mother of his three children) on the basis of two specimens she had collected, one each in New York (1960) and (with Ollie and J. F. Hanson in 1962) in Massachusetts (Flint, 1965). Much to Ollie's surprise and delight, I collected the lone Virginia specimen of *C. ruthae* in Highland County nearly four decades later (2003), a major range extension from the nearest known localities in northern Pennsylvania (see Flint et al., 2008). Ollie also named at least one species of caddisfly for his daughters, namely *Plectromacronema lisae* from Chiapas, Mexico, in honor of his middle daughter Elisabeth for her childhood discovery of this species (Flint, 1983).

Ollie was also a leading world expert on the insect Order Megaloptera and mentored several students of this group. One of the alderflies (Sialidae) that he described, *Sialis contigua* (Flint, 1964), was discovered in May 1963 by Ollie and fellow Smithsonian curator William D. Field (lepidopterist) along the East Fork of the Potomac River in Highland County, Virginia (they also collected the type series of the caddisfly *Hydropsyche potomacensis* Flint 1965 at this locality on the same trip). Ollie was also very knowledgeable about the other insect orders under his care, especially Odonata. In a 1991 paper summarizing the Smithsonian's Odonata collection, he tallied about 75,000 specimens representing 2,400 species and 424 genera (Flint, 1991). These totals have increased in the intervening three decades, largely through Ollie's collecting efforts. His publications on Odonata include a paper on Malaise trap records from Virginia, and faunal surveys of Cuba, the Dominican Republic, and Manu National Park in Peru.

Ollie was not hesitant to scrutinize the conclusions of leading experts of other insect groups under his care. During the course of his recent studies of the Mecoptera fauna of Virginia, he initially thought that some of the specimens collected by me and others, including the late Richard Hoffman of the Virginia Museum of Natural History (VMNH), might represent undescribed species. Subsequently, he carefully studied these species in great detail and concluded that the leading experts on this small, ancient order of insects had not accurately defined or delineated several species (Flint, 2013). Also, his

Table 1. North American stoneflies and caddisflies described in honor of Oliver S. Flint, Jr. The type locality (TL) is listed if it is in Virginia. The known state distribution of each species is shown in brackets.

Plecoptera (stoneflies)

Acroneuria flinti Stark & Gaufin, 1976 [VA]
Stark, B. P., & A. R. Gaufin, 1976 The Nearctic species of *Acroneuria* (Plecoptera: Perlidae). Journal of the Kansas Entomological Society 49(2): 221–253.
TL: Virginia, Fairfax Co., Bull Run Park

Megaleuctra flinti Baumann, 1973 [MD, PA, VA, WV]
Baumann, R.W. 1973. New *Megaleuctra* from the eastern United States (Plecoptera: Leuctridae). Entomological News 84: 247–250.
TL: Virginia, (Madison Co.), Hogcamp Brook, Shenandoah National Park

Trichoptera (caddisflies)

Agapetus flinti Parker, Etnier, & Baxter 2010 [NC]
Etnier, D. A., C. R. Parker, J. T. Baxter, Jr., & T. M. Long. 2010. A review of the genus *Agapetus* Curtis (Trichoptera: Glossosomatidae) in eastern and central North America, with description of 12 new species. Insecta Mundi 0149: 14–16.

Cheumatopsyche flinti Gordon, 1974 [TX]
Gordon, A. E. 1974. A synopsis and phylogenetic outline of the Nearctic members of *Cheumatopsyche*. Proceedings of the Academy of Natural Sciences, Philadelphia 126(9): 117–160.

Note: Moulton (1996, Journal of the Kansas Entomological Society 69: 272–273) concluded that *C. flinti* is a junior synonym of *C. comis* Edwards & Arnold, 1961 [NM, OK, TX].

Goerita flinti Parker, 1999 [TN, NC]
Parker, C. R. 1998 [1999]. A review of *Goerita* (Trichoptera: Goeridae), with description of a new species. Insecta Mundi 12(3-4): 228–230.

Homoplectra flinti Weaver, 1985 [TN, NC]
Weaver, J.S., III. 1985. A new species and new generic synonym of the Nearctic caddisfly genus *Homoplectra* (Trichoptera: Hydropsychidae). Entomological News 96(2): 71–77.

Lepidostoma flinti Wallace & Sherberger, 1972 [NC, SC]
Wallace, J. B., & F. F. Sherberger. 1972. New Nearctic species of *Lepidostoma* in the *vernalis* group from the southern Appalachians (Trichoptera: Lepidostomatidae). Entomological News 83(8): 222–228.

Table 2. Virginia caddisfly species described by Oliver S. Flint, Jr. and coauthors (* = type locality [TL] is in Virginia).

Brachycentridae

Adicrophleps hitchcocki Flint, 1965

Brachycentrus appalachia Flint, 1984

Brachycentrus solomoni Flint, 1984

Hydropsychidae

**Homoplectra monticola* (Flint 1965) - described in genus *Aphropsyche*
TL: Virginia, (Madison Co.), Shenandoah National Park, Hogcamp Brook just below Skyline Drive

**Hydropsyche bassi* Flint, Voshell & Parker, 1979
TL: Virginia, Russell Co., Big Cedar Creek at Rt. 19

Hydropsyche brunneipennis Flint & Butler, 1983
TL: Maryland, Potomac River (opposite Fairfax Co., Virginia)

**Hydropsyche franclemonti* Flint, 1992
TL: Virginia, Culpeper Co., Hazel River, off Rt. 707

Hydropsyche macleodi (Flint, 1965) - described in genus *Ceratopsyche*

**Hydropsyche potomacensis* Flint, 1965
TL: Virginia, Highland Co., bridge on Rt. 220 over East Fork of Potomac River

Hydropsyche rossi Flint, Voshell & Parker, 1979

Hydropsyche mississippiensis Flint, 1972

Hydropsyche opthalmica Flint, 1965

Lepidostomatidae

Lepidostoma carrolli Flint, 1958

Lepidostoma serratum Flint & Wiggins, 1961

Leptoceridae

Ceraclea ruthae (Flint, 1965) - described in genus *Athripsodes*

Limnephilidae

**Pycnopsyche pani* Wojtowicz & Flint, 2008
TL: Virginia, Botetourt Co., McFalls Creek, Rt. 618

Polycentropodidae

Nyctiophylax nephophilus Flint 1964 (placed in *Paranyctiophylax* in Flint et al. 2004 *Banisteria* paper)

Rhyacophilidae

**Rhyacophila shenandoahensis* Flint, 1958
TL: Virginia, Madison Co., White Oak Canyon Trail, Shenandoah National Park

Uenoidae

**Neophylax virginica* Flint & Kjer 2011
TL: Virginia, Clarke Co., Shenandoah River, Rt. 621

recent studies of the Virginia Neuroptera fauna led him to question the conclusions of a recent study on lacewings, resulting in a revisionary addendum (Tauber & Flint, 2010). Although Ollie was primarily a classical taxonomist, in recent years he collaborated with others on several papers concerning genetic studies of caddisflies, particularly the use of DNA barcoding (Zhou et al., 2011, 2016; Frandsen et al., 2016).

In addition to his work at the Smithsonian, Ollie was a strong supporter of the Virginia Museum of Natural History (it became a state agency in 1988), and a long-time friend and contemporary of the late Richard L. Hoffman (1927-2012). In 1993, Dr. Flint was appointed a Senior Research Fellow (one of only four) of VMNH, and he also served multiple terms on the museum's board of trustees (1986–1996, 2001–2012). In 2016, he received the Thomas Jefferson Medal for Outstanding Contributions to Natural Science from the VMNH Foundation (Fig. 6).

While the bulk of his field work was conducted in exotic places, particularly tropical America (but also Sri Lanka, Japan, New Zealand, and Europe), Ollie also collected widely in the United States as well as the southeastern portion of Canada, Carol's native country. In the early portion of his career, he conducted field work in Virginia, including trips to Shenandoah National Park, the Great Dismal Swamp (more than a decade before it became a national wildlife refuge), the Mount Rogers area, and the George Washington National Forest (especially sites in Bath, Highland, and Rockingham Cos.). Ollie and Carol were longtime members of the Potomac Appalachian Trail Club. During weekend camping trips with the club in the early 1970s, they discovered the unique boreal Odonata fauna that inhabits beaver ponds in the Laurel Fork area of Highland County (Roble et al., 2009). Ollie's first collections of Virginia caddisflies were made in 1955 and his last in 2018. In 1958, he described his first new species of caddisfly, *Rhyacophila shenandoahensis*, from Shenandoah National Park (Flint, 1958).

Ollie and Carol attended many national and international meetings and symposia concerning Trichoptera, Odonata, Neuropterida, entomology, and aquatic biology (Fig. 7), including each of the first 15 International Symposia on Trichoptera, which were held in various countries approximately every third year from 1974–2015 (only John Morse also attended the first 15 symposia). In June 2006, Ollie was honored for his life-long contributions to the study of Trichoptera at the 12th International Symposium on Trichoptera held in Mexico City (Fig. 8). He also coedited the proceedings volume of the 8th Symposium. Most recently, Ollie attended the 12th International Symposium on Neuropterology held in Mexico City in May 2015. In 1996, he received the "Award of Excellence in Benthic Science" from the North American Benthological Society (NABS; since renamed Society for Freshwater Science [SFS]). His acceptance speech concerned the role that wood-gouging larvae of the caddisfly *Hydropsyche incommoda* Hagen played in causing the deterioration and loss of structural integrity of the wooden pilings of a bridge over the Pocomoke River in southeastern Maryland, which eventually resulted in its collapse (Flint, 1996). Among various other awards that Ollie received was the diploma "Honor al Merito" from Universidad Nacional de La Plata in Argentina in September 1977. He was also a member of Sigma Xi and Phi Kappa Phi.

Dr. Flint maintained longtime memberships in numerous societies, including the American Entomological Society, Biological Society of Washington (Treasurer 1972–1977, Vice President, 1978, President, 1979), Entomological Society of Washington, International Association for Neuropterology, NABS/SFS, Societas Internationalis Odonatologica, and the Dragonfly Society of the Americas (DSA). He served on the editorial boards for the journals *Aquatic Insects* and *Journal of Neuropterology*. Ollie was one of three attendees (along with Thomas "Nick" Donnelly and Harold "Hal" White) at the 2017 national DSA meeting held in Staunton, Virginia, who had also attended the first-ever meeting of odonatologists in North America held at Purdue University in March 1963 (Fig. 9). Ollie served on the Board of Directors of the American Chestnut Land Trust from 1986–1992. He and Carol were longtime members of the Virginia Native Plant Society and often participated in local field trips of that and other similar organizations (Fig. 10).

Ollie's scientific publications span almost 70 years (1951–2019), with more papers to appear posthumously. His first paper documented a new US record of an exotic cockroach (on Cape Cod, Massachusetts), followed by two notes on hibernation in insects. He published his first caddisfly paper in 1956 (Master's thesis). Ollie collaborated with various Trichoptera and Neuropterida experts around the world, coauthoring numerous papers with them. He readily made his collections available to colleagues and students for study, resulting in a number of theses and dissertations that relied heavily on material collected by Dr. Flint (Bueno-Soria & Holzenthal, 2020). He mentored numerous visiting scientists and students at the Smithsonian, generously sharing his extensive knowledge of these taxa, especially with younger generations, as well as specimens of undescribed species (and even genera, including the monotypic *Osflintia*, described in his honor by Calor & Holzenthal [2008] nearly two decades after Ollie had recognized its uniqueness) that he had personally

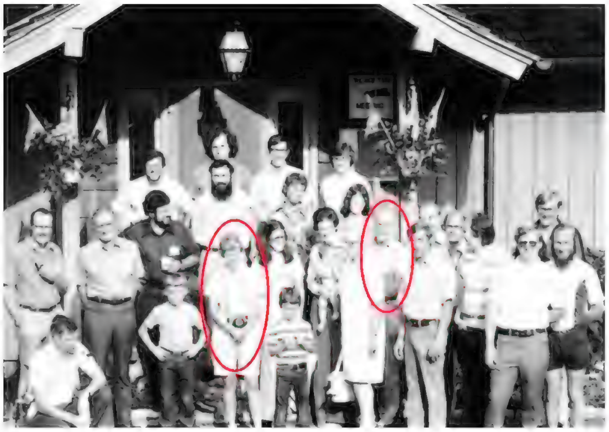


Fig. 7. Carol and Ollie Flint (circled) and fellow attendees of an informal gathering (August 28-30, 1976) of caddisfly scientists and their families at Smith Mountain Lake, Virginia, following the 15th International Congress of Entomology (John Morse photo).

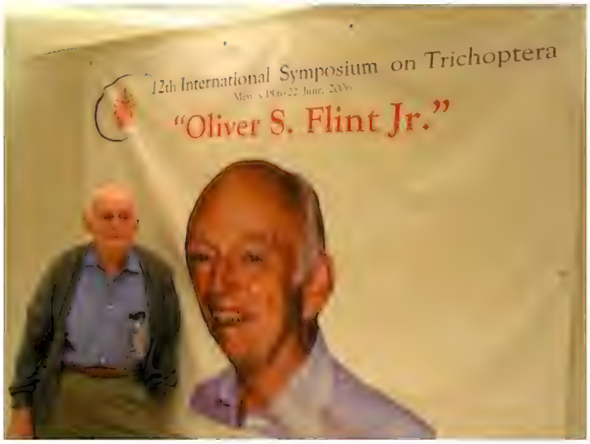

12th International Symposium on Trichoptera
"Oliver S. Flint Jr."

Fig. 8. Ollie Flint standing in front of an honorary banner presented to him at the 12th International Symposium on Trichoptera held in Mexico City in June 2006 (William L. Murphy photo, taken in the hallway outside of Ollie's Smithsonian office, February 11, 2008).

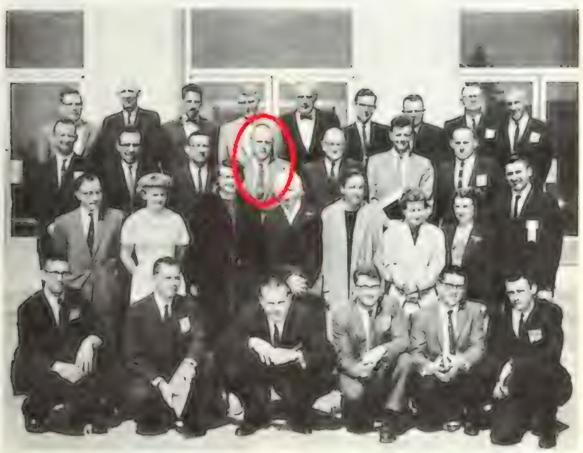


Fig. 9. Ollie Flint (circled) and fellow attendees of the first North American meeting of odonatologists, Purdue University, March 1963.

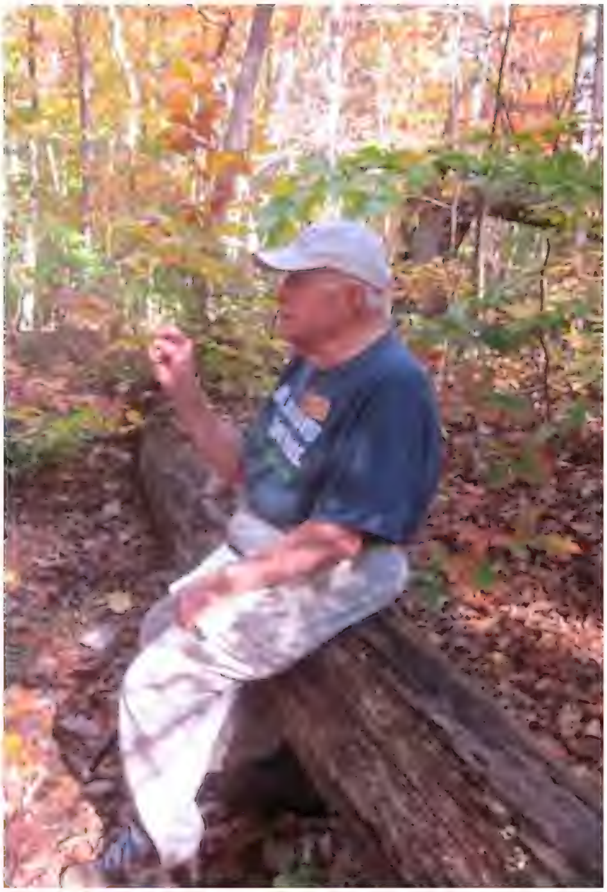


Fig. 10. Ollie Flint discussing the life histories of forest insects to participants of a hike in Holmes Run Gorge, Dora Kelley Nature Park, Alexandria, Virginia, November 2, 2013 (R. H. Simmons photo).

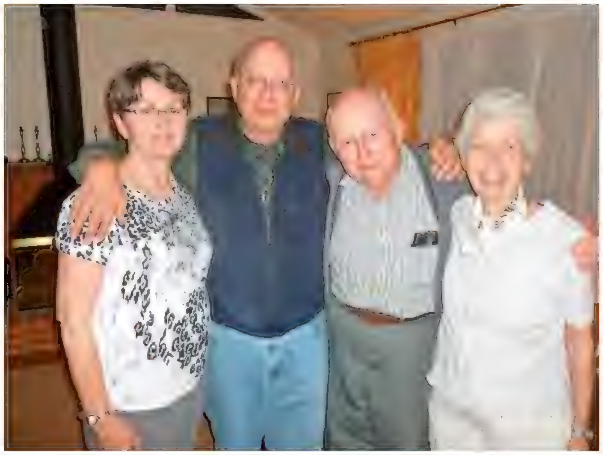


Fig. 11. Dianne and Wayne Mathis (left) and Ollie and Carol Flint (right) at the Flint residence, Alexandria, Virginia, March 20, 2012 (William L. Murphy photo).

collected. Even several of his junior Smithsonian colleagues, including now-retired dipterist Wayne Mathis (Fig. 11), regarded Ollie as a mentor (W. N. Mathis, pers. comm.). Dr. Mathis named two species of shore flies (Ephydridae) in Ollie's honor (Mathis, 1985, 1997). Ollie also collaborated with Edwin Masteller, a Penn State entomologist, on various papers concerning the caddisfly faunas of Pennsylvania and Puerto Rico (e.g., Masteller & Flint, 1979, 1980a-b, 1984, 1992).

During his career, Dr. Flint published more than 60 papers in a series he entitled "Studies of Neotropical caddisflies." In 1999, he was the lead author of an important, comprehensive catalogue of the Neotropical caddisfly fauna known as of that date (Flint et al., 1999). It contains citations of original descriptions, synonymies, and the distribution by country for about 2,200 species in 24 families and 153 genera from America south of the U.S., including the West Indies. That publication was recently superseded by an updated catalog (Holzenthal & Calor, 2017), which includes more than 1,000 additional species, nearly all of them described in the intervening two decades, many by younger trichopterologists influenced by Ollie and his scholarly works. According to Ralph W. Holzenthal (pers. comm.), a leading expert on Trichoptera from the University of Minnesota, virtually every student of Trichoptera in the past 50 years has learned from Dr. Flint.

Closer to home, Ollie was a longtime supporter of the Virginia Natural History Society. A charter member (he joined in its inaugural year, 1992), he served one term as a councilor (2009–2012) and published ten papers in the society's journal *Banisteria*, including one posthumously in this issue. I had the pleasure of editing or coauthoring all but the first of these contributions.

Post-retirement, Ollie worked closely with the late Richard L. Hoffman of VMNH (Curator of Recent Invertebrates, 1989–2012) as well as me and fellow staff of the Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR-DNH), on faunal surveys within the state. He identified thousands of Trichoptera, Megaloptera, Neuroptera, and Mecoptera specimens collected by our respective staffs, as well as those obtained during his own field work in the state. Perhaps the majority of those specimens were obtained during statewide light trapping by VDCR-DNH biologists for nocturnal insects, emphasizing moths, but also yielding large quantities of other photopositive insects such as caddisflies and stoneflies. Virtually all of the caddisflies were donated to NMNH or VMNH. We also obtained many important distributional records of Neuroptera and Megaloptera through light trapping, including a number of first state records. Ollie was genuinely interested in the collections that my staff and I made in Virginia and eagerly awaited each new batch of specimens that I donated to the Smithsonian. He typically produced a list of their identifications and significance (e.g., new state records) shortly thereafter. He was especially pleased to receive specimens of species not previously represented in the Smithsonian collection from Virginia, or species (or even genera) for which that collection had few specimens. His efforts resulted in the publication (all in *Banisteria*) of detailed summaries concerning the composition and distribution of the Virginia fauna of each of these insect orders (Flint et al., 2004, 2008, 2009; Flint, 2014, 2015), which now total 374 Trichoptera species (highest confirmed number for any US state; his coauthors were Richard Hoffman and Charles Parker, the latter a US Geological Survey biologist and fellow caddisfly expert based at Great Smoky Mountains National Park), 72 Neuroptera, and 18 Megaloptera (the combined species total for the latter two orders exceeds that of Florida [81 species; Stange, 2000]). As the publication date of the *Banisteria* issue containing Ollie's Neuropterida paper (Flint, 2015) approached, I mailed him several small shipments of vials from my most recent (and some previously overlooked older) collections at the 11th hour. These yielded several additional new state records, including an immaculate specimen of the rarely collected antlion *Chaetoleon pumilis* (Burmeister) (Myrmeleontidae) that I had captured more than a decade earlier. This was a new genus record for Virginia, and only the third specimen for the NMNH collection, the other two (both from Florida) being more than 50 years old and in rather poor condition. Ollie was especially pleased to include that record in his paper and to add the specimen to the Smithsonian collection. Ultimately, he declared "no more shipments" so that he could finalize the paper.

Ollie's post-retirement field surveys in Virginia focused on poorly sampled areas, such as the far southwestern counties of the state, as well as the Middle Peninsula (e.g., Dragon Run) and Northern Neck areas of the Coastal Plain region. Trichoptera were the primary focus of his survey efforts (primarily through blacklight sampling) in Virginia, but he also collected numerous specimens (usually diurnally with aerial nets) of Odonata and Mecoptera. If I or someone on my staff had documented an unexpected, significant range extension, multiple new state records in a limited area, or a species that he initially thought might be undescribed, Ollie eagerly asked if he could accompany me to those sites, including military bases or private property with restricted access, as well as state natural area preserves, to obtain more specimens. I thus had the distinct pleasure of spending time in the field with Ollie on multiple occasions. He later returned to some of those same sites on his own or with Carol. He was still actively collecting into his early-mid 80s. In his later years, Ollie also conducted surveys at Great Falls Park and Turkey Run Park (both are part of the George Washington Memorial Parkway, a national park in Fairfax Co.) in Virginia and Plummers Island, Maryland (Flint, 2008a-c, 2011). During the last decade of his life, Ollie collaborated with fellow retired entomologist and world renowned sawfly (Hymenoptera: Symphyta) expert David R. Smith on a Malaise trapping survey (2011–2018, and continuing by Dr. Smith) of the Bull Run Mountains in Fauquier and Prince William counties in northern Virginia. This study has yielded important new distributional information on Virginia Trichoptera (Flint, 2014, 2017) and other insect groups. Dr. Smith has named two South American sawflies in Ollie's honor (one of those also for Carol) >40 years apart, the most recent one being placed in its own new genus (Smith, 1973, 2014).

When I first learned of Ollie's plans to prepare a fascicle on the Mecoptera fauna (scorpionflies, hangingflies, and relatives) of Virginia about two decades ago, I began making a special effort to net adults (especially males) on many of my subsequent field trips throughout the state. During this period, I personally collected hundreds of specimens, including several new state records. Ollie was so excited about my 2010 collections of several boreal species from Highland County that we made a weeklong trip (with fellow Mecoptera expert Wes Bicha) in June of the following year to the same and other sites in that county to obtain additional material. Previously, he had accompanied other VDCR-DNH biologists (and later me) to several state natural area preserves in southeastern Virginia (Fig. 3) after they had discovered extant populations of the visually striking black-winged, red-bodied *Panorpa lugubris* (Swederus), an uncommon species that had not been seen in the state for several decades (Evans & Flint, 2009). Likewise, Ollie was very eager to visit the locality in Giles County where Richard Hoffman had discovered a population of the unusual scorpionfly *Brachypanorpa jeffersoni* Byers, well north of its previously known range limit in the Mount Rogers area (Hoffman, 2000). On 8 June 2010, he succeeded in obtaining a large series of this species from two nearby sites for the Smithsonian collection. At the time of his death, Ollie had nearly completed a guide to the Mecoptera fauna of Virginia (33 native species, the most known for any US state). I am currently making final edits to the manuscript, which will be published posthumously by VMNH in *The Insects of Virginia* series and include identification keys, detailed range maps, and superb color images of wing patterns and male genitalia (Flint et al., 2020). It will set a new standard for regional treatments of Mecoptera faunas.

Ollie Flint was a true scholar and gentleman, who was widely admired and universally liked. He had a pleasant disposition, friendly smile, good sense of humor, and was a humble, but highly productive scientist. He enjoyed sharing coffee and lunch breaks with his fellow Smithsonian colleagues and had many interests outside of biology, including art, music (classical), literature, history, travel, cultures, hiking, and fishing. In their retirement years, Ollie and Carol were 2010 graduates of the local tree steward class and participated in tree plantings and invasive species removal projects in local nature parks. They were also regular attendees at the local farmer's market, where they provided advice and information about insects and gardening to the general public. Earlier, they had founded a local garden club in Alexandria.

With the passing of Dr. Oliver S. Flint, Jr., an irreplaceable giant in the fields of entomology and natural history has been lost. He was a great scientist, mentor, colleague, and friend to many, including me. He will be sorely missed by his family, his colleagues in the Smithsonian's Department of Entomology, the entomological community at large, and all who had the privilege of knowing him. Dr. Flint's survivors include Carol Flint, his wife of 48 years, daughters Catherine Flint, Elisabeth Gay, and Maria Flint, and their mother Ruth, and four grandsons. A memorial service for Ollie was held on June 15, 2019, in Alexandria, and the Smithsonian Institution celebrated his life and career at an event at the museum on October 7, 2019. A blog (Dikow, 2019) has been prepared that summarizes Ollie's career accomplishments and includes the program and photos from the October event. Another obituary that includes additional information about Ollie's life and career is in press (Bueno-Soria & Holzenthal, 2020). Memorial contributions in Dr. Flint's name may be made to support curation of the Aquatic Insect and Neuropteroids collection at the Smithsonian Institution via the "Improvement of the Insect Collection Fund – Ollie Flint" (nhadvancement@si.edu) or to the Potomac Appalachian Trail Club (https://www.patc.net/).

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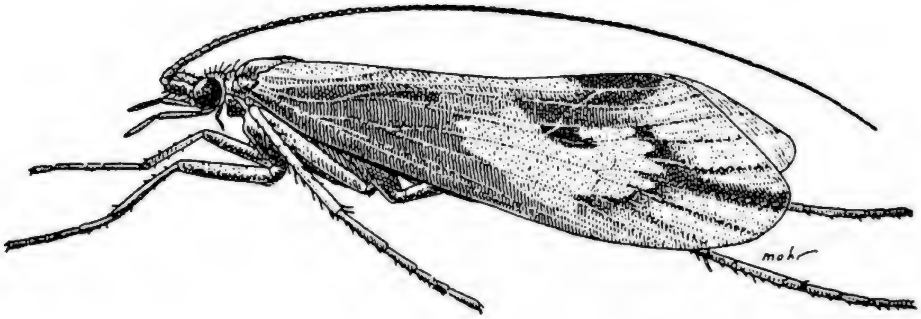


Platycentropus radiatus (Say, 1824)

[Illustration by Carl O. Mohr; from Herbert H. Ross. 1944. The Caddis Flies, or Trichoptera, of Illinois. Bulletin of the Illinois Natural History Survey 23(1): 1–326.]

Miscellanea

Reports

1. VNHS Members' Meeting

The following talks and posters were presented at the second annual members' meeting held on November 2, 2019, at the Virginia Museum of Natural History in Martinsville (an asterisk identifies the presenter if there was more than one author):

WELCOME AND OPENING REMARKS

Joe Keiper, Executive Director, Virginia Museum of Natural History

PAPER SESSION

Joe Mitchell's contributions to Virginia natural history and conservation
Steve Roble, Virginia Department of Conservation and Recreation, Division of Natural Heritage

Observations on the natural history of *Sphaeroderus schaumii* (Coleoptera: Carabidae) at G.R. Thompson Wildlife Management Area
Curt W. Harden, Clemson University

Observations of the mating behavior of the eastern Hercules beetle *Dynastes tityus* (Coleoptera: Scarabaeidae)
John C. Bunch* and Arthur V. Evans, Virginia Master Naturalists (JCB), Virginia Museum of Natural History (AVE)

Super black eyespots of the eyed elater (Coleoptera: Elateridae)
Victoria Wong and Paul Marek*, Virginia Tech

The ant genus *Strumigenys* Smith in Virginia with natural history notes on the cavity-dwelling *Strumigenys rostrata* Emery (Hymenoptera: Formicidae)
Kal Ivanov* and Liberty Hightower, Virginia Museum of Natural History

Cicadas of Virginia (Insecta: Hemiptera: Cicadidae)
Arthur V. Evans*, Kal Ivanov, and Curt W. Harden Virginia Museum of Natural History (AVE, KI), Clemson University (CWH)

Inventory and conservation assessment of the Lepidoptera (moths, skippers, and butterflies) fauna of Virginia
Steve Roble, Virginia Department of Conservation and Recreation, Division of Natural Heritage

Introduction to the Appalachian millipede genus *Cherokia* (Polydesmida: Xystodesmidae)
Fernanda Vasquez-Valverde* and Paul Marek, Virginia Tech

Phylogenetics of the Appalachian twisted claw millipedes (Polydesmida: Xystodesmidae: *Nannaria*)
Derek A. Hennen*, Jackson C. Means, and Paul Marek, Virginia Tech

Bot fly parasitism of Allegheny Woodrats (*Neotoma magister*) in Virginia
Karen Powers*, W. Mark Ford, Rick Reynolds, Wil Orndorff, Tom Malabad, Sarah Sweeten, and Margaret Short, Radford University (KP), US Geological Survey, Virginia Cooperative Fish and Wildlife Research Unit (WMD), Virginia Department of Game and Inland Fisheries (RR), Virginia Department of Conservation and Recreation, Division of Natural Heritage (WO, TM), Virginia Tech (SS), Virginia Department of Transportation (MS)

Continuing studies of bird-window collisions at Radford University: updates and analyses
Lauren Burroughs* and Karen Powers, Radford University

Genetics of melanism in the Eastern Gray Squirrel (*Sciurus carolinensis*) and the Eastern Fox Squirrel (*S. niger*)
Nancy D. Moncrief*, Nicholas I. Mundy, and Helen R. McRobie, Virginia Museum of Natural History (NDM), University of Cambridge (NIM), Anglia Ruskin University (HRM)

POSTER SESSION

Observed predation of Allegheny Woodrat (*Neotoma magister*) by Barred Owl (*Strix varia*) in Virginia
Angie Leon*, Karen Powers, Miranda Dimas, and Logan Van Meter, Radford University

Summer bat acoustic activity around VDOT bat box installations
Logan Van Meter*, Karen Powers, and Meg Short
Radford University (LVM, KP), Virginia Department of Transportation (MS)

A decade of Little Brown Bat maternity colony surveys in Virginia: observations and next steps
Logan Platt*, Miranda Dimas, Karen Powers, W. Mark Ford, Wil Orndorff, and Rick Reynolds, Radford University (LP, MD, KP), US Geological Survey, Virginia Cooperative Fish and Wildlife Research Unit (WMD), Virginia Department of Conservation and Recreation, Division of Natural Heritage (WO), Virginia Department of Game and Inland Fisheries (RR)

Impacts of the invasive emerald ash borer on ash trees in Virginia forests
Adam Allen*, Brian Ditch, Stephen Ruppert, and Christine Small, Radford University

Impacts of the Mountain Valley Pipeline: a comparison of baseline total suspended solids in control and impact sites
Angie Holmes*, Kristina Stefaniak, and Jamie K. Lau, Radford University

Effects of autumn olive (*Elaeagnus umbellata*) removal treatments on bird communities at the Radford Army Ammunition Plant
Kioshi Lettsome*, Karen Powers, and Len DiIoia, Radford University (KL, KP), Radford Army Ammunition Plant (LD)

Effects of trembolone on gonad histology in mosquitofish (*Gambusia holbrooki*)
Olivia Grubb*, Tia Strickland, Kristina Wade, Sara O'Brien, and Matt Close, Radford University

Effects of trembolone on secondary sex characteristics in mosquitofish (*Gambusia holbrooki*)
Tia Strickland*, Olivia Grubb, Kristina Wade, Sara O'Brien, and Matt Close, Radford University

The endangered ecology of Bald Knob
Kaleigh Cundiff*, Jamie Brooks, and James Pagans, Franklin County High School

The past, present, and future of Bald Knob
James Pagans*, Jade Joslyn, Xander Dobbins, and Ethan Lydick, Franklin County High School

A buzzard's eye view of Bald Knob
Jamie Brooks*, Morgan Lietz, Alyssa Hodges, and Kobie Robertson, Franklin County High School

2. Editor's Report

This is my last issue as the editor of *Banisteria,* a role that I assumed in 2000 beginning with issue #15 at the request of founding coeditors Joe Mitchell and Richard Hoffman. I thank them for believing that I was up to the task. Joe and I served as coeditors through 2007 until he moved to Florida, and I became the sole editor in 2008. A total of 2,420 printed pages have appeared in the 38 issues of *Banisteria* published since 2000.

It is a bittersweet ending to my tenure as editor that I have toiled for many hours to prepare the obituaries of my longtime friends and colleagues Joe Mitchell and Ollie Flint that appear in this issue.

Todd Fredericksen is the new editor of *Banisteria*. He has already prepared issue #53, which will be mailed together with this issue. These are the last printed copies of the journal. Starting with the first issue (#54) of *Banisteria* for 2020, the journal will only be available in electronic format. Please send your submissions for potential publication in *Banisteria* to Todd at tfredericksen@ferrum.edu.

I would like to thank the following members and non-members for reviewing manuscripts during the past year (* = reviewed more than one paper): Paul Bedell, John Brown*, Jan Ciegler, Charlie Covell*, Mike Donahue, Ollie Flint, Jason Gibson, Steve Hall*, Barry Knisley, Boris Kondratieff, Don Lafontaine*, Chris Milensky, Joe Mitchell, Weston Opitz, Eric Quinter, Chris Schmidt, Dale Schweitzer*, Warren Steiner*, and Bo Sullivan. Also thanks again to everyone else who agreed to review papers during my tenure as editor.

I would like to extend a big thank you to the friendly, personable, and excellent staff of Precision Print and Copy, a small family-run business in Richmond that has produced every issue of *Banisteria* since 2006 with great care and attention to detail.

Last, but certainly not least, I would like to thank my family for their love and support and for allowing me to devote several thousand hours on nights, weekends, and more than a few holidays and vacation days, toward editing and producing *Banisteria*. It has been my pleasure to serve the society as the editor of *Banisteria* during these past 20 years, and I look forward to reading many more issues of the journal.

Respectfully submitted,
Steve Roble
Editor, *Banisteria*

Announcements

1. Dues renewal reminder

Please renew your membership for 2020 by paying dues online or by sending a check payable to the Virginia Natural History Society to Co-Treasurer Dr. Nancy Moncrief. The website address for online payments is:

https://virginianaturalhistorysociety.com/membership/membership.htm

Beginning in 2020 with *Banisteria* #54, the journal will be distributed in electronic format only. Therefore, it is important that you provide an email address to receive the journal and other communications from the society.

All members are encouraged to attempt to recruit at least one new member to our society. Faculty members may nominate up to 3 students for a free one-year membership in the society following the guidelines presented in the Student Membership Incentive section that appears in the next column.

2. Recent publications of regional interest

Robert R. Blakney. 2019. Northern Virginia Dragonflies and Damselflies: A Field Guide. Self published; available from Amazon.com ($17.95). ISBN 978-0578460536. 109 pp.

This field guide covers 92 species of dragonflies and damselflies that can be found in northern Virginia and nearby Maryland. It includes photos showing field marks necessary for identification, flight dates, habitat, and suggested locations where each species can be sought.

Robert R. Blakney. 2015. Northern Virginia Butterflies and Skippers: A Field Guide. Self published; available from Amazon.com ($14.95). ISBN 13:978-0692383490. 70 pp.

This field guide covers 90 species of butterflies and skippers that occur in northern Virginia and nearby Maryland. It includes more than 230 photos that show field marks necessary for identification, as well as information on flight dates and host plants.

Jeffrey H. Skevington, Michelle M. Locke, Andrew D. Young, Kevin Moran, William J. Crins, and Stephen A. Marshall. 2019. Field Guide to the Flower Flies of Northeastern North America. Princeton University Press, Princeton, NJ. 512 pp. Paperback $27.95. 5 x 8¼, 3,000 color plates and 414 maps.
https://press.princeton.edu/titles/14224.html

This comprehensive field guide covers all 416 species of flower flies (also known as hover flies) that occur in northeastern North America (defined as north of Tennessee and east of the Dakotas). Along with bees, flower flies are the most important pollinators and occupy a variety of habitats ranging from backyard gardens to aquatic ecosystems but they are often overlooked because many of them mimic bees or wasps.

The guide includes more than 3,000 color photographs and 400 range maps. Each species account provides information on size, identification, abundance, and flight time, along with notes on behavior, classification, hybridization, habitats, larvae, and more.

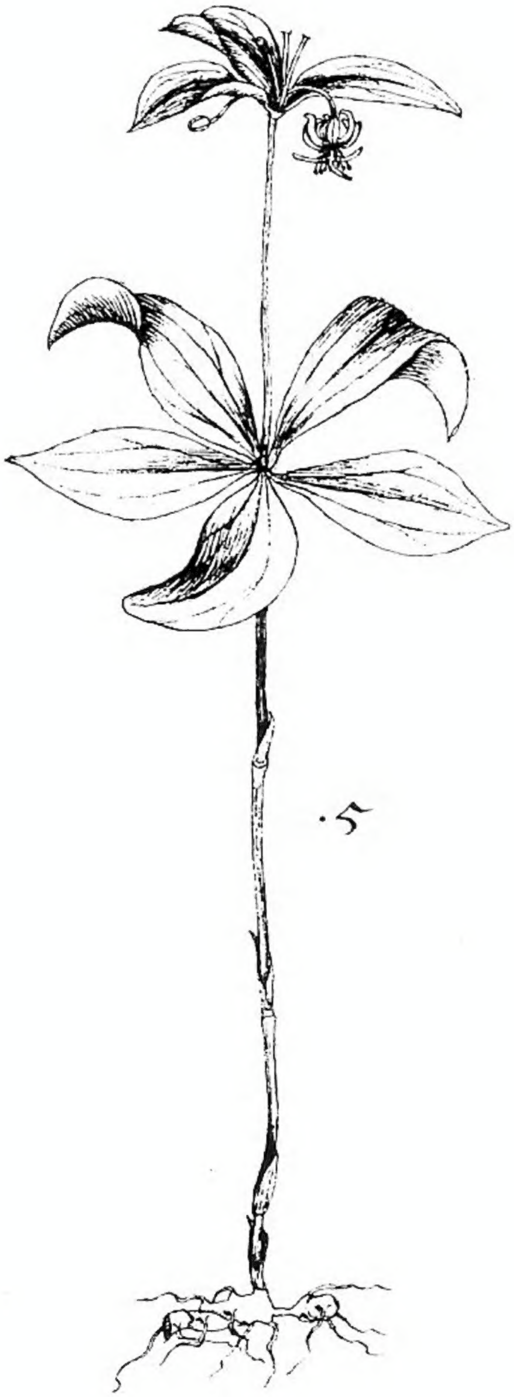
Kenneth J. Tennessen. 2019. Dragonfly Nymphs of North America. Springer Nature, Switzerland. 620 pp., 930 illustrations (8 in color). ebook $219.00; hardcover $279.99.

This monograph is the first of its kind devoted entirely to the dragonfly nymphs of North America north of Mexico, the focus being accurate identification of the 330 species of Anisoptera that occur in the region. New, fully illustrated characters provide for definite identification to the family, genus, and species levels. Life cycle data and functional morphology of various nymph features important in their survival are provided; almost no information on these aspects of dragonfly nymph biology is found in previous works.

Student Member Incentive

The Virginia Natural History Society is offering **free one-year memberships** for students (high school, undergraduate, or graduate) nominated by an advisor/teacher/mentor who is a member in good standing of the Society. This offer is available for up to 20 students each year, and nominations will be considered in the order in which they are received.

Nominators should include the following information for up to three students: name, institution, enrollment level, mailing address, e-mail address, and a short paragraph describing the student's interests in and activities related to Virginia natural history. Nominations should be sent to the Chair of the membership committee, Dr. Kal Ivanov at kal.ivanov@vmnh.virginia.gov.



Indian Cucumber-root (*Medeola virginiana* Linnaeus)

Original drawing by John Banister, sent to Bishop D. H. Compton in 1689.
Figure 82 in folio in Sir Hans Sloane's MS 4002 in the British Museum.
Photocopy courtesy of the late Joseph and Nesta Ewan.

Virginia Natural History Society

http://virginianaturalhistorysociety.com/

General Information

The Virginia Natural History Society (VNHS) was formed in 1992 to bring together persons interested in the natural history of the Commonwealth of Virginia. The VNHS defines natural history in a broad sense, from the study of plants, animals, and other organisms to the geology and ecology of the state, to the natural history of the native people who inhabit it. The goals of the VNHS are to promote research on the natural history of Virginia, educate the citizens of the Commonwealth on natural history topics, and to encourage the conservation of natural resources.

Dissemination of natural history information occurs through publication of the society's journal *Banisteria* and an annual newsletter. The first issue of *Banisteria*, named in honor of John Banister (1650-1692), the first university-trained naturalist to work in Virginia, was published in 1992. Articles cover a wide array of subjects, and prospective authors are encouraged to submit manuscripts on any aspect of natural history in Virginia; papers may pertain to Virginia or regional archaeology, anthropology, botany, ecology, zoology, paleontology, geology, geography, or climatology. Biographies, obituaries, and historical accounts of relevance to natural history in Virginia are also welcomed. Manuscripts are peer-reviewed for suitability and edited for inclusion in the journal.

The society's website contains detailed instructions for prospective authors and PDF reprints of all *Banisteria* articles that are more than two years old. *Banisteria* is indexed by Zoological Record and is available through EBSCO and the Biodiversity Heritage Library.

Memberships

The VNHS is open to anyone with an interest in natural history and welcomes participation by all members in society activities and efforts to promote education and conservation. Membership includes a subscription to *Banisteria* and invitation to an annual meeting. Annual dues for members are $20 (per calendar year); library subscriptions are $40 per year. Payments may be made online or via a check or money order sent to the Treasurer. Copies of most back issues of *Banisteria* are available for sale at a reduced price. The VNHS is a tax-exempt, nonprofit, society under Section 501(C)3 of the IRS. We welcome donations to support our mission in Virginia.

Virginia Natural History Society

Application for Membership

Name ________________________________

Address________________________________

____

____

Zip Code ______________________________

Phone _______________________________

Email _______________________________

Area(s) of Interest ________________________

ANNUAL DUES AND SUBSCRIPTIONS TO *BANISTERIA*

- ☐ $500.00 Life (not annual)
- ☐ $300.00 Benefactor
- ☐ $100.00 Patron
- ☐ $50.00 Supporting
- ☐ $40.00 Institutional
- ☐ $25.00 Family
- ☐ $20.00 Regular
- ☐ $5.00 Student (see below)
- ☐ Contribution in addition to membership dues $______

The special student rate is applicable only when accompanied by the following certification signed by a faculty advisor (**students are also eligible for a 1-year free membership** if an advisor's nomination is approved by the society's Executive Committee; see nomination guidelines in *Banisteria*).

Institution ___________________________

Advisor ______________________________

Date________________________________

Online membership registration and payments may be made at this website:
https://www.virginianaturalhistorysociety.com/membership/membership.htm

If paying by mail, send membership form and dues (check or money order payable to Virginia Natural History Society) to:

Dr. Nancy Moncrief, VNHS Treasurer
Virginia Museum of Natural History
21 Starling Avenue
Martinsville, VA 24112

Oliver S. Flint, Jr.
(1931-2019)

An obituary of this outstanding naturalist and world renowned expert on caddisflies appears on pages 74-88 of this issue.